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Materials & Methods

THE METALWORKING INDUSTRIES' ENGINEERING MAGAZINE

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NEXT ISSUE: Supply Trend of Nonferrous Metals . . . Bonding Sapphire to Metal . . . Hot Forming Nitrided Steel Parts . . . Tantalum as an Industrial Material . . . Cutting and Fabricating Stainless Steel . . . New Bonderizing Treatment for Aluminum and Steel . . . Die Castings That Cost Less Than Screw Machine Products . . . PLUS:..........Metal Congress Preview Section

The MATERIALS OUTLOOK...

More Efficient Buffing Material

A more economical "rouge" for grinding optical lenses and buffing metal articles such as silverware will result from a new binder for the rouge, a patent for which is now being taken out. It will make production of items depending on buffing considerably cheaper and faster than present methods which depend on stearic acid and other organic compounds. Present binders are often difficult to remove from the nearly-finished work. The new binder is soluble in water and few cleaning tanks are needed. Less pressure and power are needed in the buffing.

More OFHC Copper

Look for larger supplies of OFHC (oxygen-free high conductivity) copper over the next few years. Present capacity at the sole producing plant is 2500 tons monthly but through undisclosed plans a U. S. production of at least 6000 tons monthly will be a reality. Such copper is highly sought after in several electrical contact, etc. applications. There promises to be some competition between OFHC and vacuum-refined copper. One advantage of the former is that it can be operated continuously, as against batch production. Vacuum-refined copper has not been commercialized in production yet.

Aluminum Down; Steel Up

When two prominent makers of aluminum building materials, chiefly in forms of sheets and panels, reduced prices by 20% at the time that sheet steel was advanced about $6 per ton, the price differential between aluminum and steel sheets was narrowed considerably. This will undoubtedly result in a larger proportion of aluminum sheeting being used. Galvanized sheets, one of the keen rivals of aluminum, experienced the $6 rise. One new Connecticut home employs the light metal for shingles, clapboard siding, insulation, gutters, downspouts and basement windows; also bathroom tile, wallpaper for the kitchen and fluted sheet wainscoting and acoustical ceiling panels for the basement playroom.

Russia is Grabbing Metals

Better scrutinize your source of basic material to see if Russia is an active buyer and potential cornerer-of-the-market. The Great Bear is gobbling up world sources of such metals and minerals as tungsten and beryl. The Finnish nickel mine at Petsamo supplies Stalin exclusively. Moreover, many small countries under domination of the Soviets turn over the bulk of their metals to the Big One.

Metallurgical Chrome Scarce

Metallurgical chrome ore, or that which is eventually used in the steel industry as ferro-chromium and as alloy steel containing chromium, is temporarily scarce here because of delays and difficulties in getting the ore to ports from the interior, particularly in Africa. Yet in a few months this will have been rectified. Chemical chrome ore, such as for making chromium salts, used in plating, is plentiful. Zinc chromate is often supplanting red lead for giving a prime coat to steel. The over-all consumption of chrome ore and chromium in more refined forms is record-breaking, not excepting war time. Cuba and the Philippines are supplying large quantities of chrome.

Cadmium—Too Little, Too Late

Cadmium supplies will be tight for several months yet, though there has been slight improvement from the distress of three months ago. Higher prices have been a corrective to slow down consumption slightly. Thus on Dec. 2 the price was raised to $1.50 per lb., and to $1.75 on Feb. 17. Being a by-product, largely of zinc and lead, supply depends largely on conditions in those industries. Demand is normal as among uses, including plating and bearing alloys. A while back cadmium was even scarcer than lead.

Don't Overlook Rhodium

When considering bright, durable and non-porous finishes don't forget rhodium, which did good war service, such as plated on reflectors for anti-air-craft spotting searchlights—standing heat, discoloration and corrosion and giving high reflectivity. In electronics it is used for contact surfaces of radar wave guide tuning plugs. A peacetime use is on metal and glass reflectors in the movie projector field. Although a rare and precious metal and though the initial cost may seem high at first blush—actually it runs about one half cent per sq. in. for 5 millionths inch of thickness. Not too expensive, to plate a thin flash on costume jewelry, moderately-priced. It should be considered for cash registers, pen and pencil sets, trophies and display fixtures.

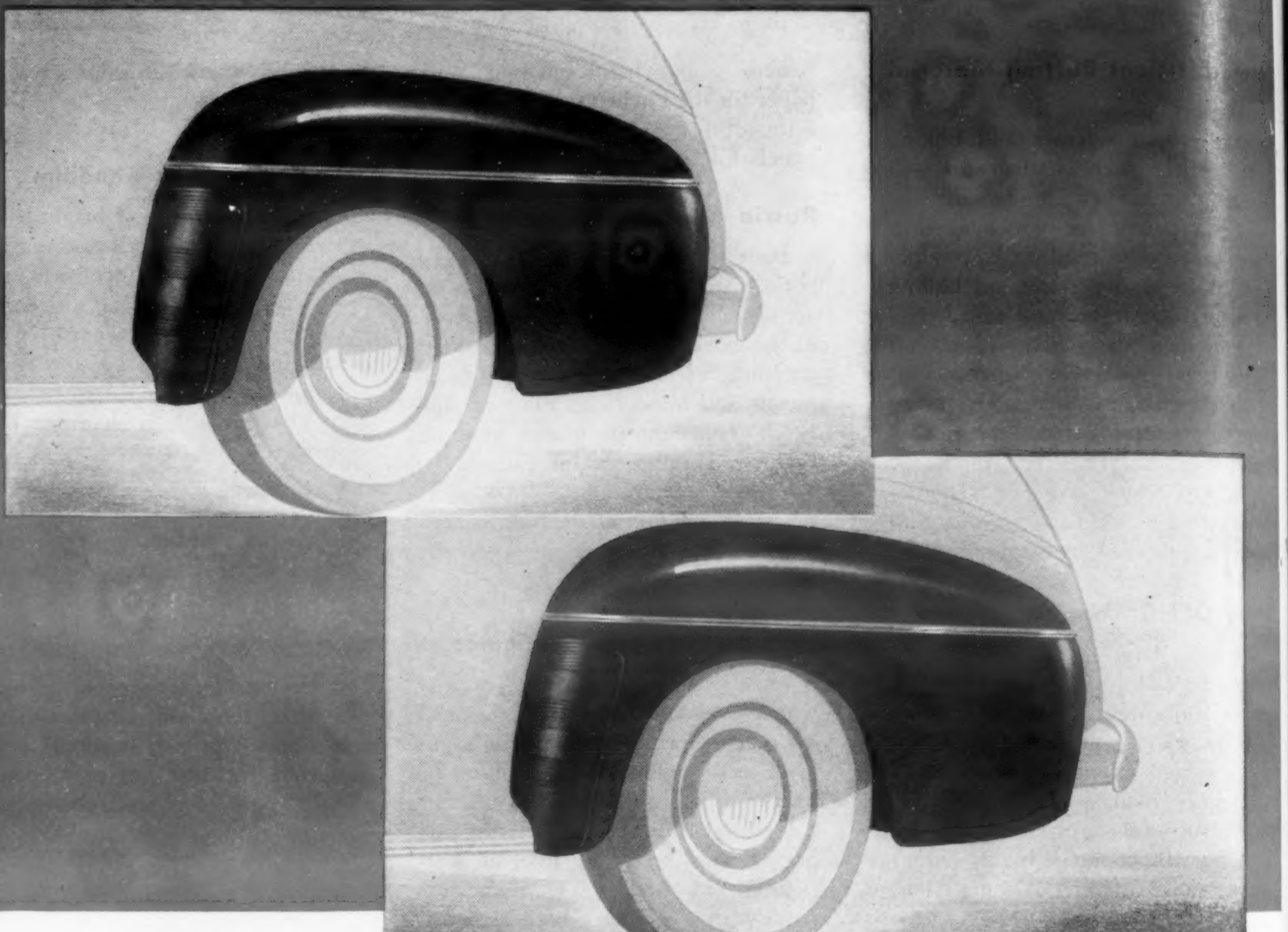
Plastics Expansion Program

Continued expansion in facilities for turning out plastics will take place over the next five years, aided by technological developments, the aggressiveness of men in a young industry and proven versatility of the products. At least $150,000,000 is being spent for expansion up to Dec. 31, 1948. All of which should result in materially lower prices, better and more tailor-made product to fit the application. A varied source of raw materials is contained in this country. Moreover, fabrication improves rapidly, with tendency towards continuous, rather than batch, production.

Industrial Sodas Improve

Supplies of silicate of soda and soda ash, used in several vital industries such as aluminum manufacture, are improving gradually after the critical shortages of last spring. By late fall a marked improvement in stocks will have been experienced.

Sure, they LOOK ALIKE from where you sit



. . . but what a difference under the paint!

One of those gleaming new fenders is regular low-carbon steel; the other is N-A-X HIGH-TENSILE.

Because of the high yield strength of N-A-X HIGH-TENSILE, fenders and similar parts made of this steel will be considerably more resistant to denting. This characteristic, combined with other desirable properties of N-A-X HIGH-TENSILE, assures longer life with less maintenance cost.

N-A-X HIGH-TENSILE's finer grain structure and higher hardness make possible a better finish without costly surface preparation.

N-A-X HIGH-TENSILE's higher corrosion (rust) resistance means that the fender will keep its new-car look and style much longer.

From any angle you look at it — manufacturer's, fabricator's, owner's—the N-A-X HIGH-TENSILE fender is far and away the better buy!

MAKE A TON OF SHEET STEEL GO FARTHER

Specify—

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HIGH-TENSILE STEEL

GREAT LAKES STEEL CORPORATION

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UNIT OF NATIONAL STEEL CORPORATION

Production Frontiers

by Harold A. Knight *News Editor*

Yes, or No, on More Steel Capacity?

The question keeps bobbing up: "Does the United States have enough steel-making facilities?" Washington and many manufacturers, such as Henry J. Kaiser, insist that it should be expanded, whereas steel makers seem agreed that what facilities we have, plus those now in process of being expanded, will be sufficient for several years. It's all very confusing.

It's like the boarding house lady who inscribed "T. M." on all her pies. Curious, the star boarder asked its meaning. "'Tis mince, it stands for," was her ready answer.

"Yes, but this is an apple pie," the star said, with raised eyebrows.

"That stands for 'tain't mince."

We might apply to the steel industry the initials "S.S.C." The Steel Institute would call that "sufficient steel capacity" but Kaiser et al would interpret it "slack steel capacity." Kaiser points out that the aluminum industry has expanded its capacity five times over pre-war. Steel ingot capacity, however, expanded only from 82,000,000 tons in 1939 to 92,000,000 tons, as of 1947.

Of course, such comparisons don't mean much because aluminum is a new industry. Undoubtedly during steel's long history there were eras near its beginning when it increased five fold in eight years.

Perhaps Carnegie's famous remark will bear repeating once more: "Steel is a feast or a famine; a prince or a pauper." Statistical books are replete with instances where the industry worked at 80% of capacity or better one year, only to sag to perhaps 35% the next.

During our days of defense preparation in 1940 and 1941 there was much pressure at Washington for increasing steel capacity substantially. The experts came forth with fantastic formulas, showing to what extent capacity should be stepped up year by year. The steel makers did increase, but not to the extent suggested by the great economist titans. As history has proved, we had enough steel to win a war, didn't we? Weren't we actually profligate with our steel?

And so again, we can't get too excited over this clamor for sharp capacity increases. We feel that realism should rule. Early this year pig lead was virtually a famine commodity. In six months supply and demand were well balanced. Copper supposedly became a semi-precious metal. But again there is fair balance.

We do believe, however, that the periodic shortages of steel scrap these several years point to the need for drastic increases in supply of raw material. Looking somewhat skeptically at sponge iron, the periodic "panacea," we conclude that our pig iron making capacity must be genuinely stepped up and that may entail corresponding increases in ore mining and water transportation—a rather elaborate program in the billions of dollars.

Searching with a "Nose for News"

As is our custom, let's look around and see what people are saying and doing. E. B. Gallaher, writing for Army Ordnance Assn., tells of a large manufacturing company where officials at individual plants grew stale and couldn't find any more things to improve. So they switched them all around and the officials found plenty wrong at the other fellow's plant.

Paul G. Hoffman, chairman, Committee for Economic Development, usually has something worth while to say. Since the beginning of the Christian era, he says, 40 billion people have lived on this earth, but less than 3% have led free lives. Rewards, under free enterprise, have nine times the pulling power of penalties, under the dictators. Excessive fear is a penalty because it corrodes and does not stimulate.

SHARONSTEEL

The steel garage doors illustrated above, built to withstand severe weather conditions, are made from Galvanite-coated Sharonsteel, painted before installation.

GALVANITE

Weatherproofed Strip Steel

Galvanite* is a patented Sharonsteel, weatherproofed with a special zinc coating that provides *real rust protection.*

Fabricators using Galvanite-coated Sharonsteel enjoy these advantages:

1. Galvanite is ideal for deep drawing and forming.
2. Galvanite's coating does not peel, flake or powder after difficult fabrication.
3. Galvanite's dry "toothy" surface makes paint or enamel spread easier and last longer.
4. Galvanite is furnished in long coils, or in cut lengths, packaged on blocks or skids for economical handling.
5. Galvanite eliminates inventory loss due to rust.

SHARON STEEL CORPORATION

Sharon, Pennsylvania

PRODUCTS OF SHARON STEEL CORPORATION AND SUBSIDIARIES: THE NILES ROLLING MILL COMPANY, NILES, OHIO; DETROIT TUBE AND STEEL COMPANY, DETROIT, MICHIGAN; BRAINARD STEEL DIVISION, WARREN, OHIO. Hot and Cold Rolled Stainless Strip Steel — Alloy Strip Steel — High Carbon Strip Steel — Galvanite Special Coated Products — Cooperage Hoop — Detroit Seamless Steel Tubing — Seamless Steel Tubing in Alloy and Carbon Grades for Mechanical, Pressure and Aircraft Applications—Electrical Steel Sheets — Hot Rolled Annealed and Deoxidized Sheets — Galvanized Sheets — Enameling Grade Steel — Welded Tubing — Galvanized and Fabricated Steel Strip — Steel Strapping, Tools and Accessories.

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"While we are seeking for measures to minimize the instability of our economic system and thus correct its weaknesses we must constantly keep in mind that its strength lies in its natural lusty vitality. That we must not lose. Otherwise, we may end up with stabilized poverty, so characteristic of the tired, regimented, old world economies."

Finally, in lighter vein before we continue with serious topics, we believe that the aluminum company promotion and advertising men, house organ editors and men of that ilk have "lusty vitality" when it comes to concocting slogans. Remember the "Imagineering" of Alcoa? Not to be outdone, Permanente comes along in their house organ with a column, "Aluminating Facts."

And we encountered this true anecdote in our travels. Of course the name "Rogers" (1847) has meant silverware to millions. In recent years a new small company was formed to manufacture the same line of goods. In making out payrolls it was found that an office boy was named Rogers. He was straightway promoted to co-owner (in name only) and the company corporate title was changed to "Rogers Silverware Co."

58 Aircraft Elements — Count 'Em!

Fifty eight elements are used directly or indirectly in production of a Martin airplane, we learn from "The Martin Star," house organ of the Glenn L. Martin Co. They range from aluminum, which comprises 35 to 40% of the total weight of the empty airplane, to zirconium which is sometimes a substitute for platinum and appears in welding electrodes, in alloys and in electrodes for power tubes.

Precious metals are well represented. Thus iridium, at $1,150 per lb., is used in low resistance electrical contacts. Platinum, which has just risen in quotation $3 per ounce as this is written, or to $58, is used in pH control meters. Gold is found in plating and for fuses in electric furnaces.

Here are the other metals used directly in the airplane. Antimony is in alloys and bearings; argon is in rectifier tubes and used indirectly in welding; arsenic is found in some alloys; barium, in bearing metals and photo electric cells; beryllium is in alloys, as electrodes for neon tubes, as an alloy for pressure pick-ups and indirectly, as windows for X-ray tubes.

Bismuth is identified with fusible alloys; cadmium is in bearing alloys and as a protective plating; caesium, in small radio tubes and photo electric cells; chromium in plating and constituent of alloys; cobalt, as alloying element and, indirectly for high speed cutting tools; columbium, as an alloy and indirectly in cutting steels; copper, for electric conductors, alloys, pipes, condensers and as plating.

Germanium is employed in crystal diodes; hydrogen, in gas rectifier tubes and indirectly, in welding; iron, in engine mounts and indirectly for tool and cutting steels; krypton, in lighting fixtures; lead, in alloys, pipes, cables and with indirect uses; lithium, in lubricants and indirectly as a protective atmosphere; magnesium, for airplane skins and as castings and forgings; manganese, as an alloying element; mercury, in thermometers and monometers; molybdenum, as alloying constituent; neon, in lighting fixtures.

Nickel is a "triple threat" metal, in alloys, electrical resistance wires and in plating; nitrogen is used to fill shock struts and to test pressure systems; phosphorous is used for electro polishing and in preparation of aluminum surfaces for painting.

Radium is found in luminous paint; selenium, in instrument and power supply rectifiers and an element in stainless steel; silicon is in insulating tapes and is used indirectly in welding rods and metal cleaning; silver is used as a solder and for plating on high current contacts; strontium is contained in photo electric cells, in lubricants and in aircraft red flares; tantalum is in radio tubes, rectifier electrodes and spark plug points, and alloyed in steel; tellurium is in electrical cables as an oxidation retarder; tin is in alloys; titanium is in steel as a stabilizer and in paints.

Thorium serves as an electron emitter in radio tubes; tungsten is used as filaments in light and radio tubes and as an alloy; vanadium is an alloy component, while xenon is in rectifier tubes; zinc is an alloy and a coating.

Other elements, which might be said to be used indirectly, function in processing and testing. Thus bromine helps analyze certain metals; calcium is used in plaster molds. Other auxiliary elements of this nature are: Carbon, chlorine, fluorine, helium, iodine, oxygen, potassium, sodium and sulfur.

All of which tickles our poetic fancy and compels us to burst out in rhyme (who cares to finish our crude beginning?)

"A" is for aluminum, used as a skin,
"B" is for barium—in bearings it's in;
"C" is for cadmium, used for a sheen;
Skip "D" and "E" to "F" in fluorine.

Dickens Discovers Aluminum

"The future place of aluminium as a raw material in all sorts of industrial applications is undoubted and we may expect soon to see it, in some shape or other, in the hands of the civilized world at large."

Now who do you suppose made that statement? "Aluminum News-Letter," house organ of Aluminum Co. of America — issue of about 1910?

Guess again. Somebody better known than Alcoa. And farther back than 1910. None other than Charles Dickens, famous English novelist. The time: 1856. The vehicle: "Household Words." And now discovered by *Light Metals,* our British contemporary.

Said Charles: "The actual presence and existence, and the remarkable properties of the metal extracted from clay, have been known for more than a twelve month past; but the minds of the public, and even of learned men, have been filled with uncertainties and doubts as to the reality of the assertion and promises that have been made respecting this curious and novel production.

"By alloying aluminium with zinc, tin, or silver, solders are obtained, whose point of fusion is much lower than that of aluminium itself, allowing the operation to be performed with a simple spirit-of-wine lamp and even without any previous scraping or cleaning (ah, there, Charlie—careful of what you say), exactly as if they were soldering silver.

(Go ahead, Charlie, don't let us interrupt.) "Aluminium is of a bright and shining white, intermediate between the colour of silver and that of platina (you mean platinum, Charles). It is lighter than glass; its

tenacity is considerable; it is worked by hammer with the greatest facility and it may be drawn into wire of extreme fineness. (Carbide or diamond dies, Charlie?) It melts at a temperature lower than the point of fusion of silver. It is completely inalterable by the atmosphere; it may be exposed without tarnishing, both to dry and moist air.

"Aluminium decidedly resists acids; azotic (what's that, Charles?) and sulphuric acids, applied cold, produce no effect whatever. Chlorydric (what on earth?) acid alone attacks and dissolves it.

"It may probably send tin to the right-about-face, drive copper saucepans into penal servitude and blow up German silver sky-high into nothing. (Harsh words, C.D.!) Henceforth respectable babies will be born with aluminium spoons in their mouths. (A clever whimsy, Charles, keep it up.)

"It is true that aluminium cannot yet compete in lowness of price with copper and tin, (Charlie, please see MATERIALS & METHODS, February, 1947: "Aluminum Versus Copper") or practically even with silver. Long industrial practice alone will attain that object. (Nice prophesying, C.D.) Science has nobly fulfilled her duty. She has discovered the metal, specified its properties and organized the means of extracting it on a large scale."

Plating Plant Explosion

An explosion at a plant at Los Angeles that was engaged in electropolishing of aluminum on Feb. 22 appalled the country because of its shocking loss of life and tremendous physical damage. Fifteen persons were killed, 151 injured, with property damage up to $2,000,000. The exploding chemicals were perchloric acid and acetic anhydride.

Interesting comments are made on this explosion and chemicals involved by the American Electroplaters' Society through their publication, *The Monthly Review* for April. One evidence of the force of the explosion was a resulting crater in concrete, 7 to 8 ft. deep and 15 ft. dia.

Over the past 10 years one authority has recommended mixtures of perchloric acid and acetic anhydride (in small quantities) for electrolytic polishing of alloys of steel, lead, tin and aluminum for metallographic examination. More recently one of the smaller steel companies has suggested such a mixture for stainless steel articles.

In view of this holocaust at Los Angeles and an even worse disaster at Texas City with another chemical, it is perhaps best to scrutinize again some semi-accepted practices and printed advice involving chemicals.

States a publication of the G. Frederick Smith Chemical Co., Columbus, "Acetic anhydride is inflammable. When mixed with 60 to 65% perchloric acid it reverts to acetic acid and converts the perchloric acid to 90% strength. The boiling point of the mixture is 248 F. Acetic acid contains combustible material and perchloric acid will support combustion at around 320 F—and this at 72% acid concentration.

"All chemicals are hazardous if not correctly used. Some are poisonous, some are corrosive, some are flammable or support combustion. The perchlorates are no exception to the rule. They are poisonous, corrosive, support combustion and have been used for explosives."

The Monthly Review then adds that numerous perchloric acid or perchlorate explosions have been reported in the literature. Chemists are fully aware of the hazards of these chemicals. Rigid precautions must be taken in their use which is best limited to very small quantities.

"We emphatically do not recommend the use of perchlorate chemicals for electropolishing or electroplating operations in metal finishing plants," the "Review" says in italics, "because the quantities must of necessity be dangerously large and it is impossible to guarantee (1) elimination of the explosive hazard resulting from contact with grease, dirt, clothing, wood or organic matter and (2) the infallibility of cooling systems and controls."

When "Labor" Really Labored

One arouses with a start at the great improvement in the lot of the plant worker over the past three or four generations when one hears stories of labor as it used to be, kept in a condition bordering on slavery. We were visiting a metals plant in Philadelphia, near the banks of the Schuylkill, in the Old Falls section. There are several metals plants in a group, including the Foote Mineral Co. At least some dozen buildings are of a horseshoe. The walls are made of there, occupied by as many companies, the group being arranged in the form round stones, like cobblestones.

And here is the story we heard from one of the present tenants. Two Scotchmen, brothers, came to this country and decided to build a plush factory. They proceeded up the Schuylkill as far as the falls and decided to go no further, as barges and canal boats could not negotiate the falls.

So they built these cobblestone buildings but never completely finished them—no mortar or cement on the outside—presumably just enough on the inside to hold them together. In short, taxes in those days on unfinished buildings were much less than on finished structures.

They imported Scotch plush workers and housed them within the horseshoe-shaped factory compound and kept them virtually as prisoners because: First, they might reveal secrets of plush manufacture if allowed to contact the outside world; second, they might be hired away by some other textile manufacturer ambitious to make plush. They were housed in 3-story hovels, one family atop another.

The Scotsmen built their offices at a strategic spot so that they could keep an eagle eye on plant operations. Perhaps they were the most vigilant around the 6:30 a.m. opening time. As the workmen filed through two bottlenecks, these workmen found one brother in each bottleneck, the employee being forced into the path of either owner Jock or co-owner Donald. Concealed behind each brother was a barrel stave.

And woe to any worker who was late! A resounding whack on the fleshy part, rearwards, greeted each latecomer, the severity of the whack being commensurate with the degree of lateness of the victim. The demon employers whacked first—and listened to any excuses afterwards.

One brother lived to 92; the other to 93. They left $40,000,000 in the coin of the realm—none to charity—all to relatives, who squabbled legally for years over that money.

Wonder if it was from these plush makers that the referring to easy money as "velvet" originated? It may have been "velvet" for the employers—but a pretty threadbare textile for their employees.

EDITORIAL COMMENT

Steel Price Investigation

It seems that the government has again gone off half-cocked in one of its anti-trust suits. This time the steel producers are the targets. Without going into the merits of the government's charges we know that at least one of the defendants in the suit is wrongly named. The suit was instituted against the American Iron & Steel Institute and its membership. From personal experience we know that as an organization the AISI has nothing to do with prices, let alone setting and maintaining prices. As a matter of fact we and other publications have no success whatsoever in extracting information on prices from the Institute or any of its employees. For years they have disclaimed any official knowledge or interest.

Such suits as this are a great nuisance to those brought into them unjustly. Too, there will be little or no fanfare if any of the defendants prove themselves to be falsely accused and they will have little opportunity of clearing their names.

It would appear to be a more sound policy on the part of the Department of Justice — and certainly fairer — if they were to be more certain of their facts before grabbing newspaper headlines by making formal charges that have little or no chance of standing up in court.

—T. C. D.

Simulated Service Tests

In the testing of materials there is often a large difference between laboratory test conditions and the conditions encountered by the material in actual service. And many times we tend to overlook this discrepancy in our efforts to simplify and speed up testing methods and procedures. This should be guarded against, because it can lead to false predictions of the performance of a material in service.

For example, the failure of some aircraft parts has been convincingly traced to definite changes in the material during service. Incompletely quenched parts, for instance, may undergo transformation at the low temperatures encountered in service and result in different mechanical properties. In such cases, testing of the parts before installation did not take into consideration these possible material changes.

Simulated service testing is a valuable means of narrowing this gap between test conditions and actual service conditions. However, up until recently it has seen most use in testing designs of parts and finished products; changes during test of the material's properties and characteristics—such as hardness and microstructure—which might affect the results, has not generally been considered.

During the past few years, the significant role of the material in such tests has been realized and some steps have been taken to develop this much needed field of testing. One encouraging step was taken about two years ago by the American Society for Testing Materials when a committee on simulated service testing was organized. The purpose of this group is to supervise the development of material tests in actual or simulated service conditions and environment, where the performance affects the properties of the materials.

It is hoped that through groups such as this, practical and reliable tests will be developed which take into account the many and varied conditions to which materials are often subjected in actual service.

—H. R. C.

Have-Not Nation?

Several of the mining and metal fraternity have in recent weeks lashed out at the "have-not calamity howlers," most of whom apparently center in Washington. Louis S. Cates, president, Phelps Dodge Corp., in combatting the estimate of only 34 more years of copper, points to the Utah Copper Co., the largest single producer in the United States. Whereas the original orebody was estimated to contain about 247,000 tons of copper, the copper content of present reserves are about 5,000,000 tons. During the intervening time hundreds of thousands of tons of red metal have been produced.

On a later occasion Howard I. Young, president, American Zinc, Lead & Smelting Co., also took issue with the Washington appraisal of only 12 more years of life for lead and 19 years for zinc. As an example, Mr. Young says: "Our mines in Tennessee have been in production for 33 years. Our proven reserves when we started operations were under 2,000,000 tons. We have mined 23,000,000 tons and now have proven around 9,000,000 tons, with large areas still undeveloped."

Robert L. Ziegfeld, acting secretary, Lead Industries Assn., in talking to the Mining Assn. of Montana in early August, cited three big lead producers, who on Dec. 31, 1937, reported combined ore reserves of 4,026,000 tons. Between that date and Dec. 31, 1946, these same mines extracted over 6,000,000 tons of ore—and reported reserves of 3,750,000 tons, or nearly as much as reported nine years before.

Clinton H. Crane, chairman, St. Joseph Lead Co., recently estimated our reserves of copper, lead and zinc are sufficient to meet all essential needs during the next hundred years.

This is only one line of argument. There are other things to be said where space permits. But these gentlemen sound convincing.

—H.A.K.

Materials & Methods THE METALWORKING INDUSTRIES' ENGINEERING MAGAZINE
SEPTEMBER 1947

Reducing Material Costs Through Standardization

by H. R. CLAUSER, *Associate Editor*, MATERIALS & METHODS

In many plants material inventories have grown like Topsy until untold varieties and shapes are kept in stock. Establishment of plant standards in sizes and shapes can save considerable time, space and money.

IN LOOKING FOR WAYS to counteract present day rising costs, materials standardization should not be overlooked. From the standpoint of cutting costs, simplification of the kinds or types of materials and their forms and sizes, offers attractive possibilities. Thorough-going standardization programs have been known to cut costs as much as 25%. On the average this figure is probably high, but cuts of 10% are by no means unusual. Even a 5% reduction in the final cost of a manufactured product is a worthwhile consideration these days. Most large concerns are very much aware of this and have groups constantly working on standardization. Although the benefits are not confined to these large organizations, in the

Uniformity of sizes and shapes of raw materials aids in materials handling as well as in keeping inventories low.

medium sized and smaller companies, concerted standardization activity is less evident. A recent comprehensive survey by the National Industrial Conference Board showed that only one out of three manufacturing companies had formalized standardization programs. Standardization is practiced, of course, but is often more like an after-thought rather than an organized, conscious effort.

Ideally, company standardization should be employed in the initial planning of a product. Often it is, but perhaps more often it is applied sometime after when the lack of it becomes more apparent. Although company standardization is primarily an engineering activity it requires the cooperation of all departments including design and planning, production, management and sales.

Standardization of materials through simplification is primarily a matter of eliminating unnecessary or excess variety for the sake of economy. So a simplification program involving materials may take one or more of the following steps: reduction of the number of kinds, types or grades of materials; reduction of the number of shapes and forms; reduction of the number of different sizes of materials used.

In carrying out material standardization programs along these lines there are some general principles that should be kept in mind. (1) Satisfactory and sufficient variety of grades and sizes must be available to accomplish the engineering result. (2) Rational selection of grades and sizes should be made to provide sufficient range of quality and quantity in economical steps. (3) Standard grades and sizes should be selected in line with national or trade practices to provide minimum cost and maximum availability. (4) Where more than one plant is involved, standards should be coordinated between plants to provide for exchange of stocks or minimize trouble in moving activity from one plant to another. (5) Adequate information on standard materials should be furnished to all operating and engineering departments. (6) The program should allow for the addition of promising new grades and sizes, first on a trial basis and then full adoption. (7) The program should provide for elimination of superseded materials and sizes with minimum cost, confusion, and change of records.

Reducing Variety of Materials

Simplification through reducing the number of different materials or grades of material used within a company, or in a product, is usually accomplished by merely substituting one grade or type for many others. The substitute may be a grade already in use, or the program may reveal a better material not previously used. To be sure that quality is not impaired it is of course important to thoroughly investigate the applicability of the substituted materials to the product being manufactured.

A typical example of this kind of standardization is the case of a plant that was using 160 varieties of steel in the manufacture of their products. The program involved a thorough investigation of their material requirements from the design stage all the way through the production line to the finished products. Thus not only were the materials tested for performance, but they were also put through all the processing operations, such as machining, grinding, heat treating and finishing, required in making the various products. The final result was the adoption of only three major varieties of steel, and two others for certain specific cases.

In another instance, a machine builder found that seven different grades of the same material were being specified for seven cams which fitted in different machines, but were of essentially the same design and were subjected to the same service. Tests proved that one grade could do the job, and so one material specification was written to cover all seven cams. In a comprehensive program at Westinghouse Electric Corp. covering nearly 1400 materials and shapes a 28% reduction in the number of specifications was realized.

When we come to the matter of finishes it might be said that here is one place where there should be no standardization; that variety of finishes should not be limited. But, nevertheless, many companies manufacturing a number of different metal products are confronted sooner or later with the problem of trying to limit the number of finishes they are using.

Standardization of finishes within a company becomes a necessity for several reasons. Far too many

shades of the same color may be used and this very soon becomes both confusing and uneconomical. The problem of nomenclature also arises. For instance, when "light blue" is specified, what does that mean? The term "light blue" is largely a matter of personal opinion and certainly varies with different people. Identifying and buying finishes by trade names also becomes confusing and uneconomical. Two companies might make the same color and quality of finish, but the finishes have different names. All this can easily lead to an unwanted cumbersome variety of finishes.

One way to solve this problem is to make sample panels of all the different finishes used. Then all the people concerned—design, engineering, production and sales—are called together to decide on what finishes should be kept. Invariably, a number are eliminated outright. In many cases one finish will take the place of several others. For example, in one company, nine different shades of "black" were being used. This number was reduced to three.

To avoid the use of manufacturers' and trade names each of the retained finishes is given a letter-number designation. Sample panels of these standard finishes can then be made up and posted in all departments concerned. Such a system is flexible because at any time when a definite need for a new finish arises it can be easily added to the standard list.

Sizes and Shapes

Only a superficial survey of almost any company's products and methods will usually reveal many possibilities for standardization or simplification of raw material sizes and shapes. But the number of material sizes is a difficult matter to control because undesirable variety is built up from many different sources. Two very important sources of variety are often beyond the control of the individual plant. These are national practices on fits and tolerances, and existing variety in standard size and gage-number systems. For example, there are at least six different gage systems for thin materials, each for certain types and forms of materials. So in designing a part for 1/16 in. stock, if made from strip steel it will be actually 0.065 in.; if made from sheet, it will be 0.060 in., and if made from brass it will be 0.064 in. Much has been done in recent years by the American Standards Association, to reduce this variety by the introduction of the "Preferred Numbers" system. They have issued American Standard Preferred Thicknesses for Uncoated Thin Flat Materials, which covers standard thicknesses for all thin metals from a few thousandths up to ¼ in. In time as the American Preferred Numbers become known and more widely adopted by both the metal producers and manufacturing concerns, this source of variety should diminish.

Another source of an excess variety of material sizes is the lack of company standards. One plant stocked 45 different thicknesses of steel between 0.016 and ⅛ in. to take care of all its design requirements. This is a natural outcome where there is no system of telling designers to what sizes of materials they should try to limit their designs.

To eliminate unnecessary sizes and shapes, the dimensional requirements of raw material stock should be analyzed, and then a set of sizes and shapes established which could be used in great majority of applications. In most normal design work, a change of a few thousandths in material size can be tolerated.

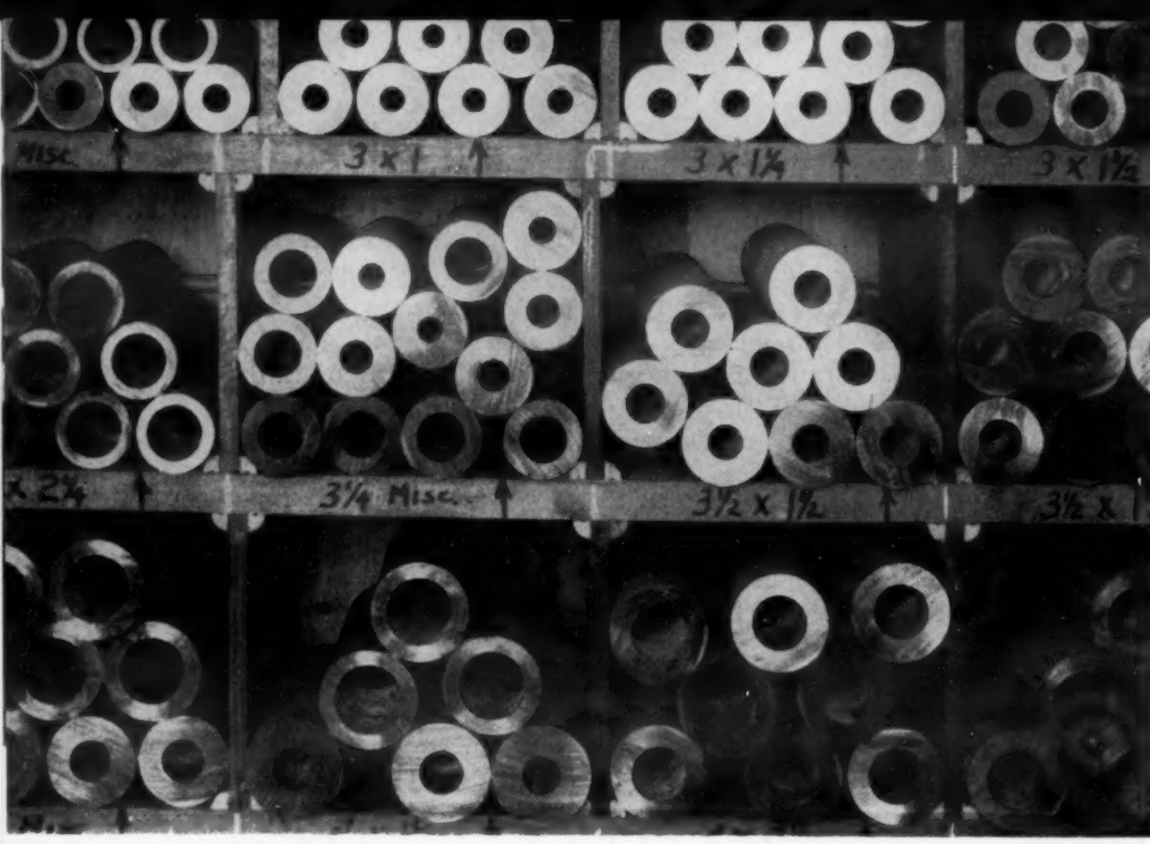
The Preferred Numbers system will often offer a sound basis for company size standards. The Penn Electric Switch Co., faced with the need to reduce an unnecessarily large inventory, used the American Standard Preferred Numbers (Z17.1-1936) as the base of their standardization program. Preferred Numbers are based on a series of numbers in geometric series starting with 10 and increasing in approximately 60% steps; the basic numbers are 10, 16, 25, 40, and 63.

In establishing standard sizes of sheet metal and strip they set up a table of primary and secondary thickness values between 0.006 and 0.250 as follows:

Primary	Secondary
0.006	0.008
0.010	0.012
0.016	0.020
0.025	0.032
0.040	0.050
0.063	0.080
0.100	0.125
0.160	0.200
0.250	

As will be noted from the table there are only nine primary, and eight secondary thicknesses. The primary sizes are considered standard for design

Standardization is not restricted to sizes and shapes, but can also be applied to the analyses of the materials.



Even though the size of finished parts may vary it is often more economical to standardize on a few sizes which are adequate to meet all requirements.

purposes. To use a thickness other than primary, written approval must be obtained from the Chief Engineer, and in such cases secondary sizes must be used wherever possible.

This system has worked out satisfactorily for over a year now. The same set of thicknesses are used for specifying ordinary steel, brass, aluminum, and stainless steel, and makes possible a reasonable inventory. One important advantage is that changing from one material to another is greatly simplified. For example, in the case of a shortage of brass, another material, such as aluminum, can be substituted since all the materials are available in the same thicknesses.

Attempts either to cut down on direct labor costs or reduce waste sometimes result in excess size and shape variety, as well as false economy. It is not always more economical to buy material to very nearly finished dimensions. The extra cost for an off-standard size may be greater than the savings that result through its use. In one case extra charges of 5 to 8 cents per lb. were incurred by buying a special size to avoid labor costs. Later it turned out that the labor cost for machining down standard stock was only 0.25 cents per lb.

Unfamiliarity with manufacturer's tolerances on nominal sizes may also result in uneconomical practices. In one specific case a plant ordered a large amount of sheet material in different thicknesses in the range of from 0.030 to 0.130 in. A number of the sizes varied only 0.001 in.; for example, thicknesses of 0.125, 0.127 and 0.128 in. were ordered separately, when a single mill size of 0.127 in. could have been ordered for all three. Actually, the tolerances of the supplied material in this particular case were no better than 0.002 in.

Specifications

Specifications and establishing standard tests is another very important phase of materials standardization, and in many ways is closely allied with simplification. After materials which will be standard have been selected it is often necessary to have a means of defining them. Their characteristics and the test limits of their various properties must be listed in order to assure uniformity. Specifications are the means of doing this.

A classic example of developing materials standards is the comprehensive program conducted by Bell Telephone Laboratories to set up specifications for nonferrous materials going into contacts. Metal contacts are one of the fundamental mechanisms used in the communication field and it was found that brass, nickel-silver and phosphor bronze were the most suitable materials for these parts. In setting up specifications to insure uniformity of these materials it was found that three types of tests were needed. One was an identification test, and chemical analysis was settled upon. A basic or reference test to be used as a basis for acceptance or rejection was also required; the tensile test was found most suitable. And third, a quick test for inspection was needed; for this the Rockwell hardness test was adopted as most satisfactory.

Along with the working out of suitable tests, specifications requirements for these materials were developed. Rolling series to all the various tempers for each commercial gage thickness, were tested to determine the hardness and tensile strength limits. Thus specification limits were set up and then tried out on commercial shipments of the nonferrous sheet materials. Then based on the laboratory data as well as the experience data the final specification was written under the auspices of the American Society for Testing Materials.

Advantages and Results

What are the results and advantages that may be expected from standardizing materials? A number of them, although not directly stated, have already been implied. Perhaps the most tangible one is the savings in the material costs that results from buying in larger quantities and thus minimizing extra charges

for small quantity orders. These extra charges alone can often add as much as 5% and sometimes more to the material cost. The reason for these extra charges is obvious. Like in almost everything else, in producing raw materials, as variety increases, cost of production usually mounts rapidly. For example, to roll only 5 tons of a certain steel shape costs $8.80 more per ton than to roll 100 tons; in another case the extra cost amounts to $12.95; and in a third case the excess is more than $15.00 per ton.

Small quantity orders in themselves are not always bad. They sometimes cannot be avoided. Where small quantities must be used, selection of standard types or grades, and sizes may in many instances avoid extra charges. When standard items are involved the supplier can often consolidate a large number of small orders for execution.

"Over-ordering" quality is another thing that standardization of materials tends to eliminate. It is not always wise to select the best possible material for a part. In many cases the "best" grade is just too good for the service intended, and a grade below the "best" quality would be perfectly satisfactory. Specific demands for chemical composition and mechanical properties, or for dimensional tolerances not in accordance with standard specifications complicates manufacturing of materials and this invariably is reflected in increased cost. By proper analysis it is often found that standard types and grades of material have ample quality for the job. In one case, a small shaft for an electric motor was being made of a steel with a specially specified chemical analysis. Actually the steel differed only slightly from a standard composition and investigation showed that the standard steel was satisfactory for the part. The resulting saving was nearly 50% in material cost and improved delivery time by several weeks.

Standardizing of materials, thereby limiting variety, also tends to simplify production methods. The materials going into a product greatly influence processing methods. Such things as machinability, weldability and formability, often vary widely with various materials. Generally, the smaller the number of different materials, or grades of some material, that are handled the less are the production problems. Where a large variety of steels are used, for example, it becomes almost impossible to standardize heat treatments. In order to get satisfactory heat treating results it is often necessary to have elaborate control equipment. Even then inadequate heat treatments may result.

Closely related to this simplification of processing is the increased efficiency of labor resulting from reducing material variety. The fewer number of materials the men have to work with the more familiar and efficient they become in handling them. In welding operations, for example, techniques vary considerably with different materials and frequently a man who is proficient in welding one type material must be retrained to satisfactorily weld another type.

Perhaps less obvious than the other results of standardization are the savings in indirect costs, which are less tangible. These indirect costs include such things as inventory counts, purchase orders and other paper work, storage space, testing and inspection and many others. To illustrate, let's take a case where five products are being manufactured which are all quite similar in general design, but vary perhaps in size or function. In each of the five machines there is a part performing a similar function and is subjected to essentially the same service conditions. As often happens where there is lack of standardization, the five parts may be of different design and five different grades of material may be specified. The sizes of the raw stock may also vary.

In order to standardize on the material going into these five parts it may be necessary to adopt one of the more expensive of the five material grades to meet the service conditions in all five machines. In such a case the direct cost of the parts would be increased, but this increase in many cases might be off-set by a larger saving in the indirect costs. If one instead of five different materials were used, specifications would be reduced from five to one. Only one materials test and inspection would be required. One instead of five purchase orders and follow-ups would be needed. There would be only a single stock item to be received and counted and handled, and only one set of stock bins instead of five different sets. (It might be said that just as much space is needed to store 500 lb. of a single material as to store five different materials of 100 lb. each. But actually, to store five different materials at least double the space is required.) There would be one set of inventory counts instead of five; and one material requisition and tracer ticket and follow-up.

If, in addition, the design itself would be standardized, the number of patterns and dies, the machining set-ups and teardowns, the jig, special tools, and inspection gages might also be cut from five to one. When the savings from all these small intangibles are added up, the standardization would be probably more than justified in spite of possible higher direct costs.

Finally, perhaps the greatest advantage gained from standardization is that it requires analyzing products and production processes as a whole. It is directly opposed to piece-meal methods of planning, and instead requires over-all cooperative effort which usually leads to savings otherwise overlooked.

It should be pointed out in closing that materials standardization, through simplification, is not a spectacular method whereby costs are dramatically cut while production is made to soar. But it is a sound, engineering approach to materials selection. If used properly, it can assure selection of the most economical variety of materials without loss of quality in the final product.

We wish to thank the following organizations for their help in supplying information for this article.

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Precision Drop Forging of High Temperature Alloys

by S. G. DEMIRJIAN, *Thomson Laboratory, General Electric Co.*

THE PRECISION DROP FORGING of alloys, especially for high-temperature applications, is a separate and distinct branch of forging practice. The forging of such alloys began to take great strides several years ago at the Lynn River Works of the General Electric Co. At this time turbosupercharger bucket forgings were rapidly being replaced with precision-cast Vitallium buckets.

Vitallium alloy possesses high hot tensile strength, good ductility, good weldability and more especially, high stress rupture strength, probably the most important property necessary to a turbosupercharger bucket. The superiority of the cast alloy over the forged alloy for this size of piece and application was substantiated by actual performance results. The alloy was cast practically to size in enormous quantities with very slight variation in dimensions from bucket to bucket. The small amount of bench work required to finish the buckets eliminated many costly machining operations performed on forged buckets. Thus, the overall cost of producing cast supercharger buckets was much cheaper than forged buckets.

When high temperature alloys came into use it appeared that forging would be eliminated as the method of producing such parts as turbine buckets. However, close control over heating and forging temperatures produced parts having properties superior to their cast counterparts.

Some of the properties required of a good bucket alloy are as follows:

1. High Fatigue Strength
2. High Stress Rupture Strength
3. High Hot Tensile Strength
4. Good Ductility
5. Good Weldability
6. Good Damping Properties
7. High Thermal Shock Resistance
8. High Creep Strength

The River Works forge shop immediately realized that it would have to prove that bucket forgings could be produced in quantities to the dimensions the design engineer needed. The advent of the jet engine furnished just that opportunity. In this case the cast buckets failed to fulfill expectations because, being a bigger bucket than the turbosupercharger bucket, difficulty was encountered in controlling the grain size, which has a profound effect on the necessary fatigue strength. Also, in general, forged alloys inherently have a higher endurance limit than cast alloys.

After a series of important developments in forging practice, the forged jet engine buckets were proved to possess more uniform grain size, more

accurate dimensions, more ductility, and higher impact strength.

It was at this time that the metallurgists and engineers turned to forged jet engine buckets, thus inaugurating precision forgings.

The first bucket alloy used in jet engines was Hastelloy B, which has the following approximate composition:

C	Mo	Fe	Ni
0.10	28	6	65

This alloy is one of the toughest high-temperature alloys to forge. However, under careful and expert handling it can be forged and processed with a high degree of success. All of the forging and treating of this alloy was done in electric furnaces in the presence of a controlled reducing atmosphere.

In forging the large buckets for some of the Type I-40 jet engines, it was necessary to upset the bar stock in a press following which the upset slugs were grit blasted before proceeding to the actual forging of the bucket. An accompanying illustration shows the sequence of operations required to produce a forged bucket, and shows that a large quantity of material is required to fill the base section.

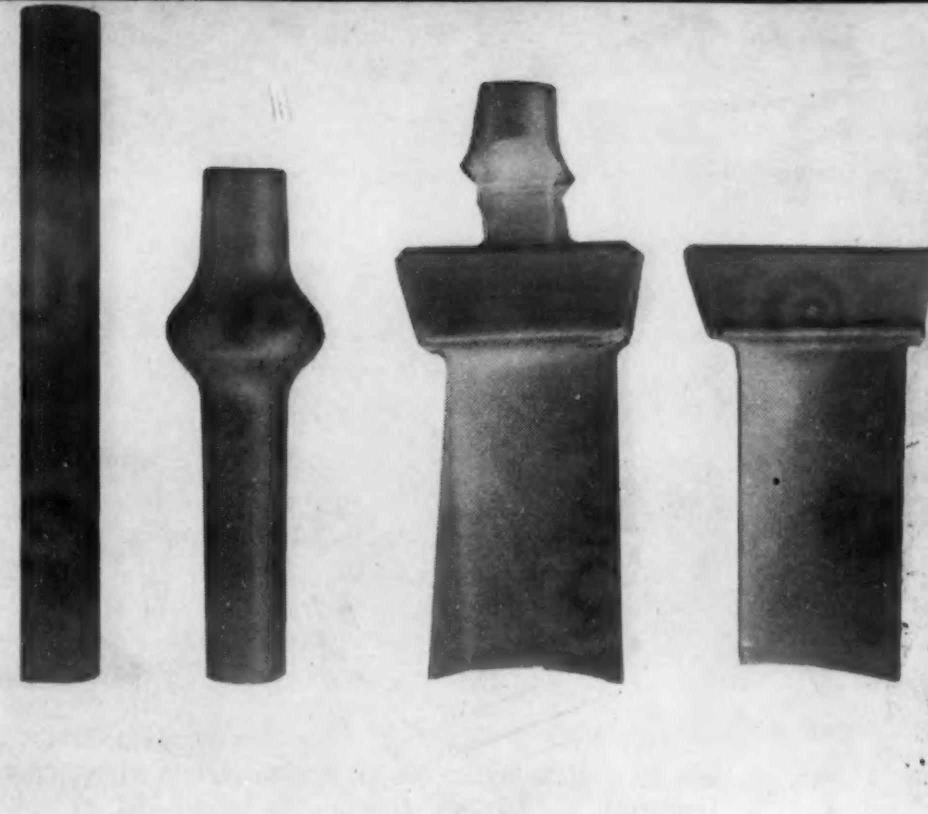
Upsetting Efficient Starting Point

Obviously, the most efficient and inexpensive method of forging the bucket is to start with bar stock of sufficient diameter to fill the blade, and then upset a section of the bar to a diameter sufficient to fill the base. Some of the advantages of using an upset slug over straight bar stock are savings in material cost, increased furnace capacity leading to increased production, less time to forge bucket, less wear on forging dies, and less wear on trimming dies.

Slugs upset in a solid die have been more satisfactory than those upset in split dies or those obtained by rolling on a board drop hammer. Slugs upset in split dies tend to form flash lines where the dies come together, with the possibility of forming as many flash lines as there are passes required for the complete upset. These have to be ground out to prevent the formation of forging folds. In rolling the slugs there is a tendency to form folds and laps which likewise have to be ground out before forging the bucket. Rolling may also produce center bursts, which means scrapping the slug.

In general, a higher temperature can be used in upsetting than in the actual forging of the buckets. It is essential to control the amount of upset for each pass to prevent internal bursts and cracking of the material. Once the upset section has begun to take shape, the amount of upset per blow for the subsequent passes can be increased over the first two or three passes. Whether in upsetting the slugs or forging the buckets, care must be taken to soak the material thoroughly to insure a high degree of plastic flow with no accompanying cracking.

Some of the nickel-or cobalt-base alloys should not be pickled prior to forging. Some of these alloys inherently tend to have a large amount of carbide segregates, which are readily susceptible to acid attack, and in this condition appear to act as stress



Typical of forging procedure are these four steps taken in producing an open end bucket. First (left) a slug is prepared and upset, next the slug is blocked and finally it is trimmed to final shape.

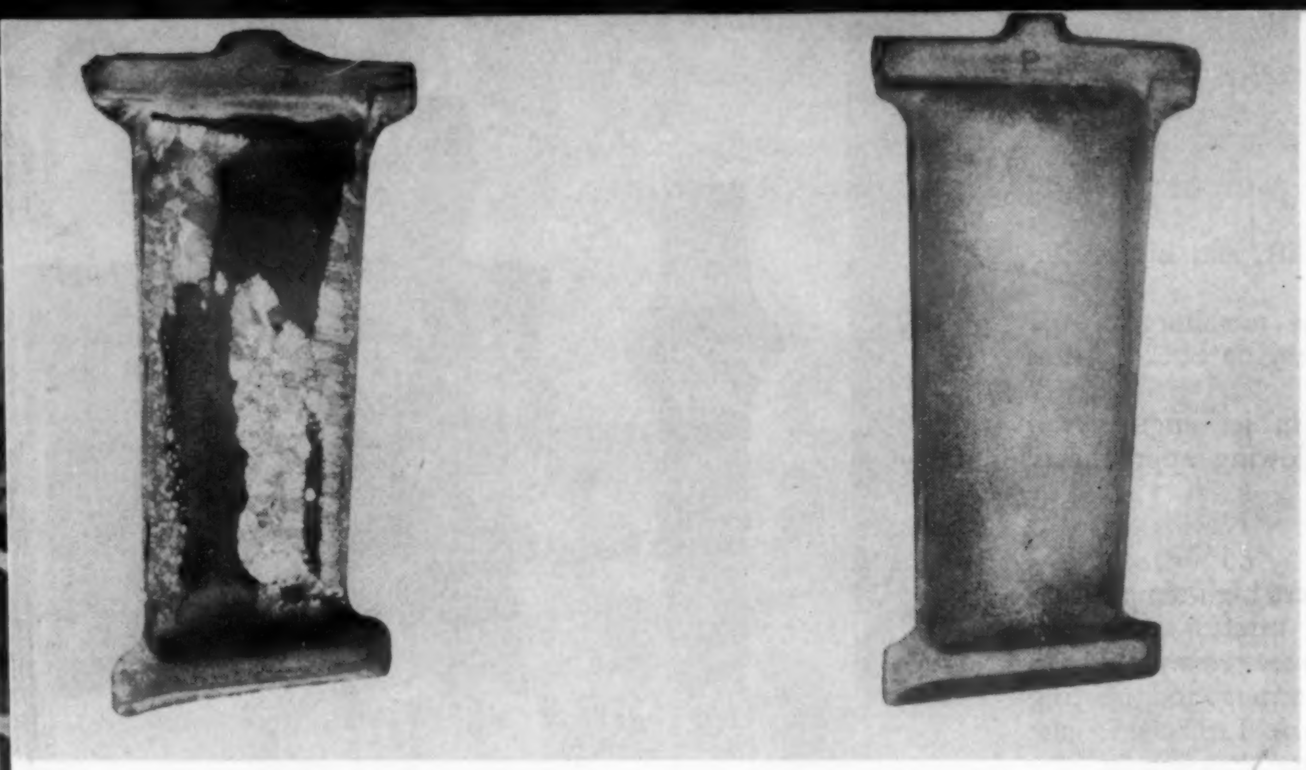
raisers and to crack upon subsequent forging.

The Hastelloy B upset slugs are soaked thoroughly at the high heat in electric atmosphere controlled furnaces, and then blocked out (a rough forging operation) on a 2000-lb. board drop hammer. The first few blows of the hammer must be "dragged" (Struck light blows) in order to prevent a rapid flow of the metal which will result in cracking. The buckets in this stage are shot blasted. They are then first-finished (a semi-finish forging operation) on another set of dies on a 2000-lb. board drop hammer. The buckets are rapidly approaching the required dimensions. Again the buckets are shot blasted, followed by forging to finish dimensions on a third set of dies (the final finish forging operation) on the same type of hammer.

Obviously, whenever the flash begins to spread and diminish the flow of metal at any stage, then it must be trimmed. The trimming must be done hot to prevent the trimmer from chipping and wearing too rapidly, and also to prevent the formation of fine transverse cracks at the edge of the blade of the bucket, which tend to open up on subsequent forging.

The buckets are then heat treated to produce a spheroidized structure which is the most stable for Hastelloy B. Following the heat treatment, the buckets are sand blasted with very fine beach sand. Now the buckets are given a final sizing operation at room temperature by cold striking them in the final finish dies. The salient features of the cold striking operation are to remove all high spots on the blade and produce a perfect contour. The other operations performed on the finished forged bucket are machining the base, side grinding the flash from the blade, putting the edge radii on the blade, and, if necessary, polishing the blade lightly to remove the skin of oxide.

Although this alloy, Hastelloy B, does not appear to possess a high degree of plasticity at the forging temperature, it can still be forged to a lower finishing



Finishing temperature has considerable effect upon the quality of forgings of high temperature alloys. At left is the result of too low a finish forging temperature and too high a solution treating temperature. The part at the right was properly finished and solution treated.

temperature than most of the high-temperature alloys without impairing the metallurgical properties, and thus can withstand a little more abuse. The finishing temperature of most high-temperature alloys has to be controlled in order to prevent the formation of a differential grain size structure upon reheating above the recrystallization temperature. In some cases, cold work in the critical region to the extent of half of one per cent is sufficient to cause the differential grain size, and this indicates how critical the finishing temperature can be.

S-816 Suited to Buckets

Coincident with the development of the axial-flow-type gas turbine a new alloy known as S-816 came into the picture. This is a cobalt-base alloy and possesses to a high degree most of the aforementioned essential bucket properties. It is more resistant to corrosion than Hastelloy B and also has a higher fatigue and rupture strength. This also is a forged alloy.

The approximate composition of S-816 is as follows:

C	*Cr*	*Ni*	*Co*	*W*	*Mo*	*Cb*	*Fe*
0.40	20	20	42	4	4	4	4

It will be readily noted that this is a complex alloy. It is particularly sensitive to any marked change in the ratio of columbium to carbon content. By maintaining a satisfactory range, consistently high stress rupture values can be obtained, whereas a marked change of either one of these two elements will produce erratic results. Best results have been attained by working to a range of 8Cb:1C to 11Cb:1C.

This alloy is used for gas turbine buckets, and is forged at a slightly higher temperature than Hastelloy B. However, being more plastic, this alloy must be broken down a little more slowly in the blocking stage to prevent the formation of cracks. Also, it is susceptible to the formation of a differential grain size and thus must be finished at a high forging temperature while at the same time avoiding too high a solution treating temperature. This is a precipitation hardening alloy that must be solution treated and aged to produce the good all around metallurgical properties that it is capable of developing.

Vitallium, probably the foremost cast bucket alloy, has been successfully rolled and forged, thus lending possibilities as a forged bucket alloy. It forges readily with a minimum of scaling. The limited data on its properties as a forging prevents its immediate use as a production alloy.

There are also other alloys that look promising as bucket materials and for obvious reasons cannot be divulged at this time. This includes alloys that at one time were considered as strictly cast and non-forgeable alloys, but which more recently have been forged successfully, and thus fit themselves into a dual role.

The forging of nozzle diaphragm blades of Type 347 stainless or compressor blades of Type 403 stainless employs essentially the same principles as those required in the forging of buckets. However, these two types of stainless do not prevent the forging problems that the bucket alloys do, since the latter are more complex in composition and more heat resistant.

It is well to point out that cold working of alloys for precision bucket forging applications in the precipitation hardening range of 1200 to 1500 F should be avoided. Not only is there the danger of forming tiny cracks, but the ductility of the alloy diminishes markedly. This was proven by prestressing tensile specimens of some of the more prominent high temperature alloys at different temperatures, and then preparing and studying micro specimens of each condition.

Too much emphisis cannot be placed on the type of forging furnaces used. A great deal of success has been obtained with controlled atmosphere electric furnaces to which are attached electric automatic controls. The temperature gradient from side to side and front to back should be small to prevent overheating, excessive grain growth, and subsequent embrittlement of the material.

It is also well to repeat that a careful check should be maintained of the soaking time for optimum plastic flow.

Forged Under Controlled Atmosphere

An atmosphere with an approximate analysis of 12% carbon monoxide, 6% carbon dioxide, and 0% oxygen has been successful in forging the aforementioned alloys. This will keep the scaling down to a minimum and thus decrease wear on the dies. Some alloys are inherently susceptible to a very slight surface oxidation (less than 0.002 in.) even in this type of atmosphere, and this skin of oxide must be removed by polishing or electrolytic pickling after the bucket is forged. This surface intergranular attack would penetrate through the bucket under the combined operating temperatures and stresses, and eventually the bucket would fail if the cause of attack was not removed. Care must be taken to avoid atmospheres which would carburize the bucket alloy during the heating prior to the forging operation.

Die Stools for Forging

Another important item that cannot be overlooked is the dies, including die design. Over twenty grades of die steels were used during the war and the most successful was of the following approximate analysis:

C	*Cr*	*Mo*	*W*	*Mn*	*Si*
0.35	5	1.75	1.25	0.50	1.00

The heat treatment of this material, as well as any other die material, must be closely followed in order to obtain as near as possible a duplication of structure from die to die. Caution must be maintained to employ heat treating furnaces or packing compounds, if the dies are pack hardened, that will not carburize or decarburize the surface of the dies.

The recommended heat treatment for this grade of die steel is as follows:

1. Preheat at 1450 F.
2. Air quench from 1800 to 1850 F. (Under mild air blast).

It has been determined that it is necessary to vary the hardness of the dies to fit the type of material being forged. In forging the bucket alloys for high temperature applications, a hardness range of 45 to 48 Rockwell C has been highly satisfactory, while the higher range of 53 to 56 Rockwell C has been successful in forging nozzle diaphragm blades and compressor blades of Types 347 and 403 respectively. Generally speaking, a lower hardness is required to forge the tough materials than those with a high degree of plastic flow.

The dies themselves should be designed to use a minimum of the material being forged and, above all, to insure as much as possible an equal rate of flow of the metal from side to side. If the rate of flow of the metal is not equal, it can cause rupturing of the surface layers of metal. In some instances improper die design will cause folds or other surface imperfections, especially on parts with sharp fillets. The dies should be wide enough or long enough, or both, in order to withstand the impact of the repeated blows of the hammer.

At all times the mechanical setup of the dies in the hammer should be checked. In the case of some of the insert type dies it has been found that a die has cracked due to the loose manner in which the key was driven in between the side of the die and the holder. Sometimes a taper has been detected in the holder, and this causes trouble not only in the dies, but makes it difficult to obtain the proper dimensions of the part being forged. Finally, if shim stock is used, it should be hard.

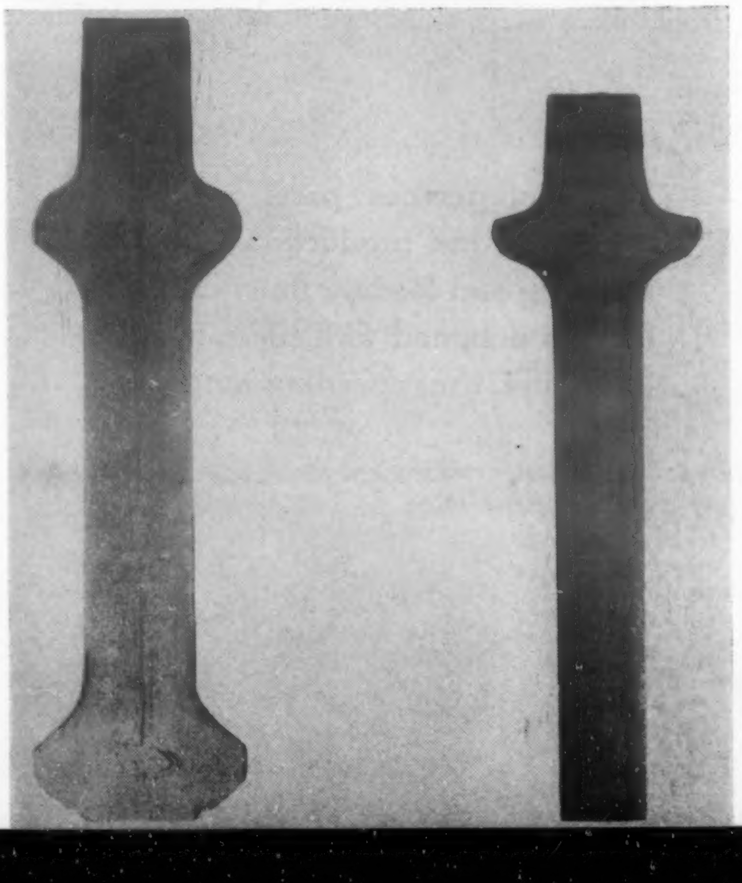
Here again, soft shim stock can throw the dimensions off. Once more the importance of the furnace atmosphere is mentioned. If excessive scaling of the alloy to be forged is allowed, due to an improper atmosphere, it will act as an abrasive and cause rapid wear of the dies. In addition, the scale is likely to become imbedded in the forging.

The most common lubricant used in forging alloys for high temperature applications has been air-floated graphite mixed in oil. Molybdenum sulfide mixed with oil has also been used with some degree of success. An excess of lubricant should be avoided to eliminate the tendency to form oil cracks.

The future of forging the type of alloys in question looks brighter still. Pressing gas turbine buckets, compressor blades, and other parts is in its infancy but promises to rival drop forgings. The foremost problem in pressing is dies. Preliminary work on pressing has failed to produce a die material that will stand up satisfactorily. The dies appear to wash out readily. The cure to this might lie in putting a hard, wear resisting surface, either by nitriding, chromium plating, carburizing, or some other means, on the die material.

The writer acknowledges the suggestions of Messrs. W. L. Badger and R. B. Johnson and the assistance of his associates in the Thomson Laboratory in the preparation of this article.

These cut-away views show the grain flow of upset slugs of S-816 (left) and Type 403 stainless (right).



Forged aluminum spray gun parts are speedily aligned and machined at the Electro-Cycle lathe at Black Mfg. Co.

New Lathe Increases Production on Nonferrous Parts

by T. C. DU MOND, *Managing Editor,* MATERIALS & METHODS

RECENTLY DEVELOPED AND NOW IN SERVICE in more than 100 plants throughout the country is a new lathe which was designed to make easier and faster the machining of nonferrous metal parts. The lathe, known as the Electro-Cycle and manufactured by Warner & Swasey, has shown significant increases in production on parts made of brass, aluminum, rubber and plastics.

Since most of the nonferrous metals and the machinable nonmetallics are readily machined at high speeds, it is not unusual for loading and unloading time to exceed total machining time. Thus, Warner & Swasey engineers worked towards a lathe that would place starts, stops, reverses and speed changes of the entire machining cycle under automatic control. Much of the time saving possible is attributed to an automatic spindle positioner and an air chuck which are employed as integral parts of this new equipment.

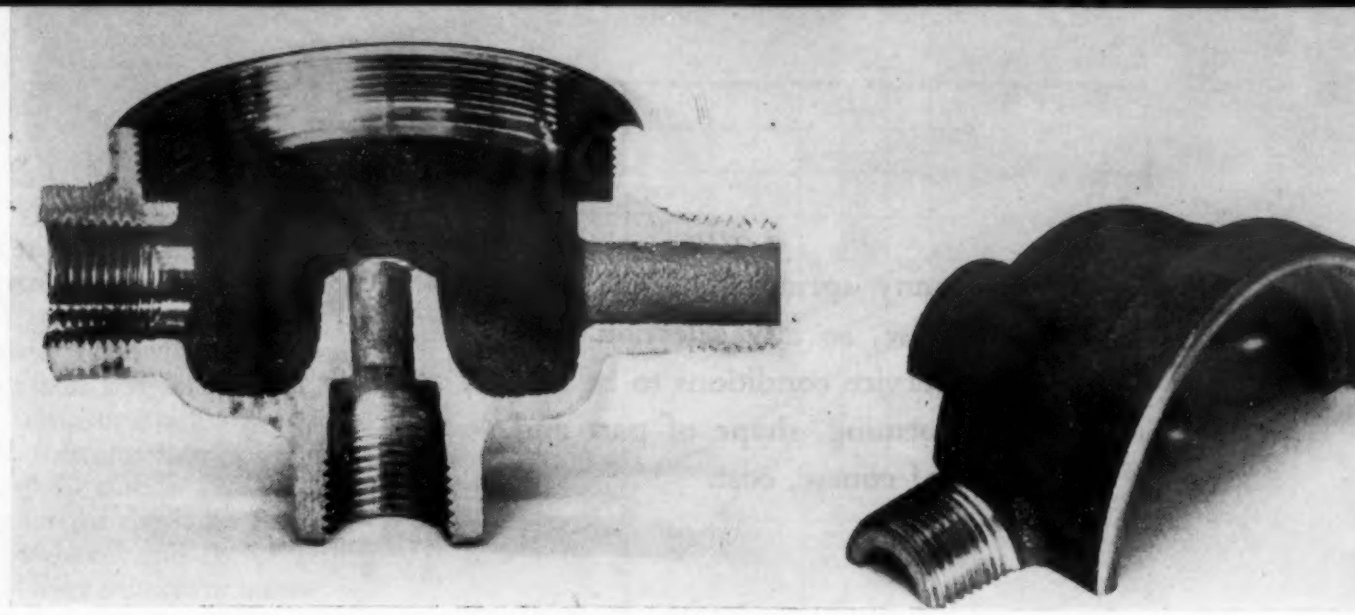
Many nonferrous parts are readily machined, but production is lost due to set-up and loading time. This new lathe is designed with these points in mind, thus speeding output.

Speeds comparatively higher than most general purpose machine tools are provided on the new lathe. For most cutting, the top speed range of from 1,000 to 2,000 rpm. is suitable, while half speeds of from 500 to 1,000 rpm. are used for threading. The Electro-Cycle can handle 1½-in. bar stock or will swing 16⅞ in. over the bed.

The greatest factor in providing a rapid work cycle is a method of automatic control which reduces handling time. The control is accomplished through a series of four control drums mounted on the ram. Each drum controls one spindle function. Setting its six knob indicators, which represent each of the six turret faces, will engage or disengage the drum's function in proper sequence.

Thus, a twist of the knobs across the four drums in the positions corresponding with each turret face in turn sets up the necessary automatic control of starts and stops, right- and left-hand rotation, high and low speed and reverses for threading. The drums are actuated mechanically by indexing of the turret in either direction.

In combination the drums take over the load of manual control formerly borne by the machine oper-



Automatic fast reverses and speed changes aid in turning and threading these relief valve bodies.

ator and, by handling the sequence in a consistent minimum of time, increase production through a substantial saving in floor-to-floor time.

Increased Production with Various Materials

One company producing spray gun parts from aluminum forgings has increased production by 217% over former methods. Of this increase on a part which is irregular in shape, 45% is credited to the air chuck and spindle positioner. Requirements are such that work pieces must be aligned on a positioning pin in the chuck and clamped between special jaws that accommodate their shape.

In a shop producing brass plumbing fixtures it has been estimated that increases average about 5% per turret face after the first one, plus 7.5% increase for each threading operation in a given work sequence.

At a Chicago plant which works rather extensively with brass forgings in lots of from 1,500 to 20,000, some 20 parts are machined on the new-type lathes. The parts range in weight from 4 oz. to 1 lb.

An example of the saving in handling time is cited by another concern making fittings and valves for breweries. Work transferred from old cone-head lathes was produced on an average of 74.9% faster on the Electro-Cycles. Setup time is approximately 12 min. per tool as compared to 30 min. per tool previously. Lots on the 22 different jobs assigned to the new lathes range from 100 to 10,000 pieces.

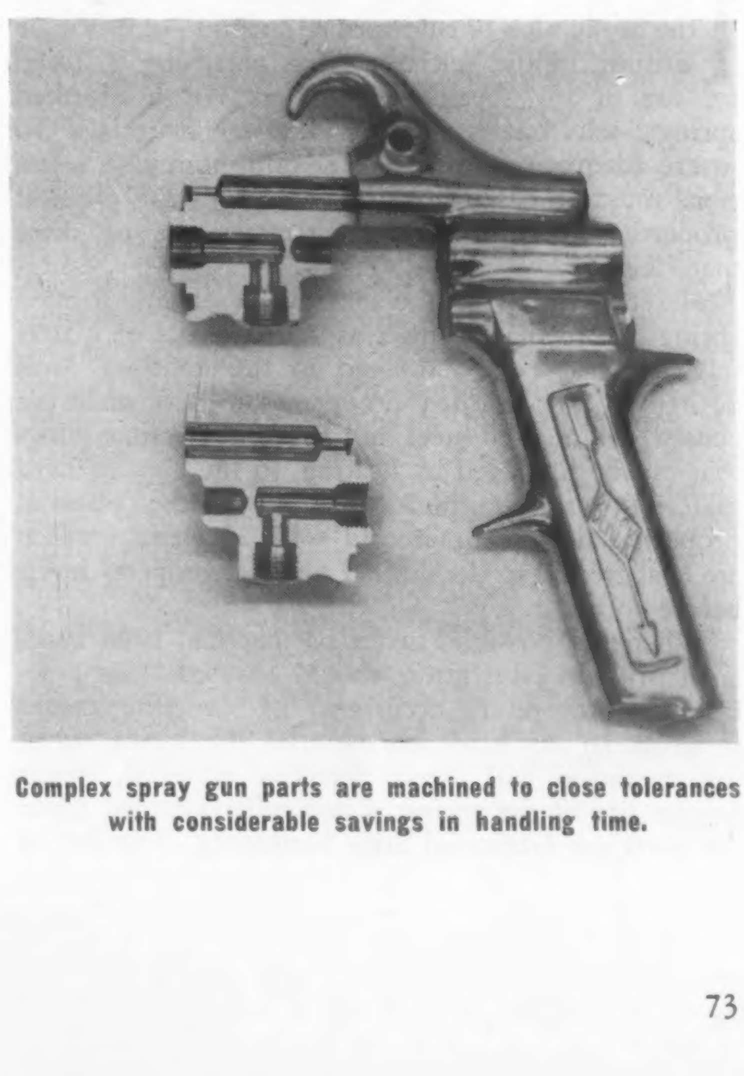
In still another installation, housing assemblies for small electric motors are machined to close tolerances. The drum-shaped housing consists of a drawn steel case sized to match the 2.678-in. dia. steel stamping that forms the other end.

Centered in the end of the case and in the flange stamping are 5/16-in. lengths of bronze bar 5/16 in. in dia. These bars are pressed in and staked. When finished, they become bearings for the motor's armature.

The flange, 0.062-in. thick, is held on an expanding arbor. The bronze part is center drilled, drilled and reamed to 0.1248 in., with tolerances of plus 0.0007, minus 0.0020 in. The o.d. of the flange is turned and the bearing chamfered. Then with the spindle stopped, the latter is burnished with a ball broach to 0.1255 in., within a plus 0.0005-in. tolerance and a finish of 10-micro-inches. The housing case and its bearing are similarly handled except that the 0.049-in. thick steel is faced and counterbored to receive the inset flange.

Although feeds and speeds are the same on this equipment as with former machines, a total production increase of 17% was achieved on the housing case and 18% on the flange.

Actual field experience with plastic parts production is rather limited, but since the machining and handling problems of plastics are somewhat similar to many nonferrous metals, the Electro-Cycle is recommended for many plastics.



Complex spray gun parts are machined to close tolerances with considerable savings in handling time.

There are many spring materials from which to choose, so any selection must be based on service conditions to be met, methods of forming, shape of part and, of course, cost.

Selecting, Testing and Fabricating Spring Materials

by F. P. ZIMMERLI, *Chief Engineer, Barnes-Gibson-Raymond Div., Associated Spring Corp.*

This article was adapted from a paper presented at the Summer Meeting, Society of Automotive Engineers, June 1-6, 1947.

THE variety of spring materials available for the production of cold-formed springs permits wide latitude in the selection of a particular material for use in any specific application. For hot-formed springs, selection is limited to fewer materials. To insure adequate performance at minimum cost, selections must be based on a knowledge of the physical properties and formability characteristics of these materials.

Materials used for the fabrication of cold-formed springs are available either as soft material or materials that had been hardened to the hardness level desired in the finished product. The soft materials consist of annealed steel and some nonferrous alloys that can be hardened by heating. In the class of hard materials, are all those materials whose physical properties depend upon cold work and those which are heat treated to the desired physical property levels before forming.

Whenever possible, materials that had been hardened prior to fabrication, should be used. This practice will prevent the occurrence of hardening cracks in steels. In any hardened material, the spring forming operation will detect defective material. Better fatigue life of the spring is generally obtained when the parts are fabricated after hardening. The use of soft materials is restricted to those complicated parts that can not be formed from the hard materials.

Flat Steel Springs

Materials available for flat steel springs are oil tempered steels, SAE 1095, 1074 and 1064. Of these, SAE 1095 should always be used pretempered while the other two can be obtained annealed.

The use of oil tempered 1095, a poor hardening steel in heavy sections, is common in thin clocksprings and simple forms. The Rockwell hardness will correspond to C 51 to C 48, C 48 to C 45, and C 45 to C 41, in the normal three hardness ranges available to the commercial users as a standard article. The material has a modulus of elasticity of 30,000,000. The tensile strength varies with the hardness and thickness from 310,000 psi. at 0.005 in. thick with the highest temper to 190,000 psi. at 0.065 in. thick with the lower hardness. Many ordinary clock springs are stressed to 200,000 psi. in thicknesses of 1/16 in., while 0.010 in. thick springs carry 250,000 to 275,000 psi., when wound up tight. For an ordinary cantilever spring of finite life, a stress of 180,000 psi. can be employed. If a spring must give infinite life, the endurance range varies with thickness. When the springs are to be subjected to heat, stresses must be lowered as the temperature increases, until above 400 F, the stress becomes so low as to render springs useless from this steel.

The other two steels can be obtained and used successfully either pretempered to the same Rockwell ranges or in the annealed state. When used in the hardened state, these steels will form better at equal Rockwell readings as the carbon and manganese contents are lowered. More uniform results from annealed steel hardened after forming into springs are obtained with the 0.70 to 0.80 carbon content. The drawing temperature is higher for the same Rockwell than the 0.60 to 0.70 carbon steel and the resulting conformation to specified dimensions is more accurate. Over 1 in. wide and 1/16 in. thick springs should be made of the 0.70 to 0.80 carbon steel.

Flat steel in alloy grades, such as SAE 6150, or 9260, is infrequently used in mechanical springs. In thin sections the higher hardenability is not needed and fatigue results do not exceed carbon steel. There are some uses of these steels to resist heat where a higher stress is present than carbon steel will stand and the use of more expensive material is not warranted.

Stainless steel of the 18:8 type is employed in flat springs since it will resist the effects of heat much better than carbon or alloy steels. The material will have a hardness range of Rockwell C 38 to 41 and a possible tensile strength of 180,000 to 200,000 psi. in the thinner sizes. The material will respond to shot peening and the fatigue life will be increased thereby. Electro polishing on either unpeened or peened parts will cause a lowering of the endurance limit by about 10% of the endurance range, while a nitric acid passivation will do less than one-half of this amount of damage.

Carbon Steel Springs

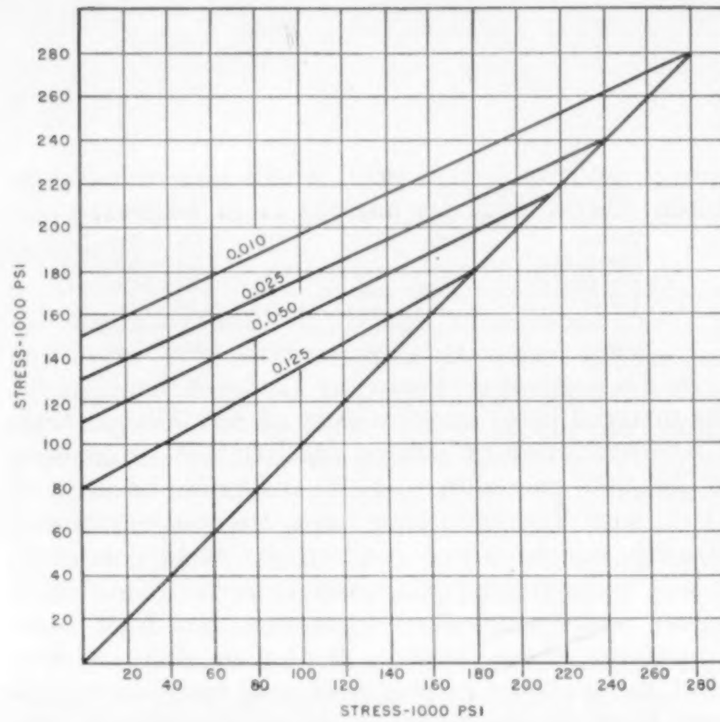
The cheapest wire for cold-formed spring is hard drawn wire. Detailed specifications for this material are listed under ASTM specification A 227-41 and SAE 1066. It has a carbon content of 0.60 to 0.71% and a manganese content of at least 0.80% and is cold drawn to definite physical property ranges. The surface of this material is poor and its physical properties show considerable variation. It is suitable only for unimportant springs.

One of the most common cold-formed spring materials is oil tempered spring wire. This material is reduced by cold drawing from 50 to 70% in cross-section. It is then heat treated and oil quenched in a continuous process.

The physical properties of oil tempered spring wire are listed in Table I. This type of material has rather poor surface characteristics and is not often used in critical applications.

Valve spring wire is the highest quality oil tempered carbon steel wire. Its chemical analysis is similar to that of the oil tempered spring wire. However, special care taken during fabrication and heat treatment results in a product that has uniform physical properties and excellent surface condition. Its fatigue properties are uniformly high and the material is widely used in those applications that require dependability and consistent performance.

Music wire is the highest quality cold drawn wire.



Safe endurance limits for 0.70 to 0.80 carbon steel flat springs having hardness of between 45 and 48 Rockwell C, tested as cantilevers.

It is reduced about 80% in cross-sectional area by cold drawing through 8 to 10 operations. During the drawing, the wire is passed through a liquid containing tin salts which produce a slight tin deposit on the wire. This lubricates the wire and results in a very smooth surface.

If heated to 375 to 425 F after forming, the physical properties of the wire will increase slightly. If heated to 700 to 725 F, the physical properties will drop slightly but the resistance to heat is increased and the fatigue limit increased somewhat and made more uniform.

Music wires should usually be used for cold-formed springs with a wire size of less than 0.028 in. dia. It can be used in sizes up to ⅛ in. in diameter. In sizes over ⅛ in. dia., it is usually more economical to use oil tempered alloy spring wire which will have equal or superior physical properties.

Alloy Steel Wires

One of the most common alloy steels used in springs corresponds to SAE 6150, called chromium vanadium by the spring industry. This material can be obtained oil tempered or annealed in valve spring quality or at higher hardness used in guns for some recoil springs. For springs of high endurance, this material is usually purchased Rockwell C 43 to 47. For extreme stresses where a short life can be anticipated, this is increased to Rockwell C 50 to 53. In sizes of ⅜ in. or less, it has no higher endurance limit than regular carbon steel or valve spring quality. It does, however, produce springs that settle less under temperatures up to 425 F, than carbon steel. In neither temperature resistance nor in absorbing shock loads does chromium vanadium steel equal either chromium silicon or silico-manganese steels by a considerable margin.

The war brought to the front in the cold-formed

spring industry a new steel, which was called chromium silicon steel. Its analysis is as follows:

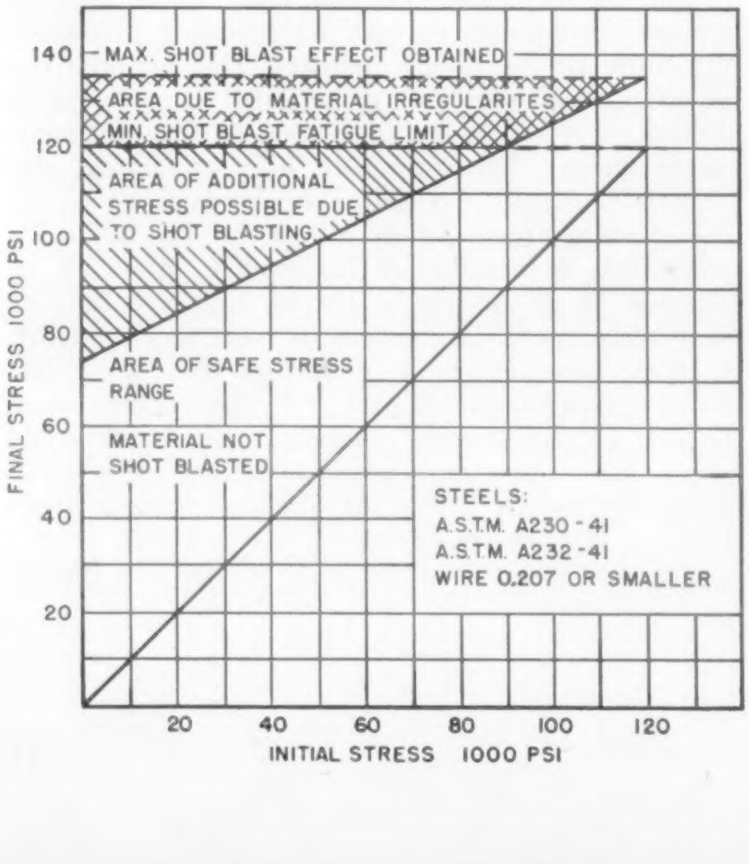
Carbon	0.50 — 0.60
Manganese	0.60 — 0.80
Phosphorus	0.04 Max.
Sulfur	0.04 Max.
Chromium	0.50 — 0.80
Silicon	1.30 — 1.60

In the pretempered state, at Rockwell C 50 to 54, the material gives tensile values of 325,000 psi. with a 50% reduction of area in size 0.035 in., decreasing to 265,000 psi. with a 42% reduction of area in ⅜ in. wire. The endurance limit, after or before shot blasting, equals carbon steel in the same condition. It will withstand equal stresses at better than 100 F higher temperature than chromium vanadium steel. Chromium silicon steel is harder to draw with a good surface than carbon steel and, since its endurance limit is the same at room temperature, the material offers little advantage over carbon steel for springs where temperatures of 375 F, or less, are encountered and impact or high stresses are not a consideration. One great value of this steel is the possibility of using it at extremely high stresses and hardness. It will then give an excellent result for a short life cycle, depending upon loading conditions of from 5,000 to 100,000 cycles. It can be coiled into springs with a 5 to 1 mean diameter to wire size ratio at 52 C Rockwell.

Silico manganese steel, SAE 9260, was also greatly developed in the smaller wire in sizes during the war. With 50 to 54 C hardness, a tensile value of 300,000 psi., with a 50% reduction of area in size 0.035 in., can be obtained. As the size increases to ⅜ in., the tensile will drop to 250,000 psi., with a 42% reduction in area. The steel can be interchanged with chromium silicon, giving practically the same results if all conditions are equal.

When springs must withstand elevated temperatures, best results are obtained with steels having the highest carbide concentration. Thus, 18-4-1 tungsten high speed steel or the 6-6-2 molybdenum type are equally good. At a total combined stress of 40,000 psi., 700 F is handled and, by cutting this stress in half, springs handling 800 F have been produced successfully.

Stress range of pretempered wire. (Stress corrected by Wahl factor.)



Stainless steels have been used with varying success and several analyses have been tried. To date, the best steel is SAE 30915, or Type 302. This material can be drawn in sizes from 0.003 in. to 5/16 in. with good results. The tensile strength ranges from a minimum of 350,000 psi. for the small size to 160,000 psi. for the 5/16 in. Its stresses range is about 20% less than valve spring wire for sizes of 5/32 in. or less, and ⅓ less as sizes increase to 5/16 in. The steel shows good resistance to heat and, if properly treated and pre-set after forming into the springs themselves, the material will set less than steels other than high speed steel at 500 F. The amount of set at 600 F sometimes precludes its use for accurate results.

One of the troubles encountered in using this steel is the fact that its modulus varies with different wire mill practices. The higher temperatures to which parts made from stainless steel are heated after forming, the more this fault is corrected, so that the steel approaches a true modulus of 28,000,000 in bending, or 10,000,000 in torsion. At no time should this stress relief be less than 825 F, and 1000 F will not harm the physical properties. Stainless Steel is not non-magnetic despite its being listed as an austenitic steel. The smaller the wire or the thinner the flat sections, the surer it is to be magnetic.

Stainless steel of the 16:2 type has the same modulus as steel. Its use has been somewhat limited because the price differential is not very great and, with 18:8 available, pressure for its development is light. The addition of molybdenum in amounts of 2 to 3% to 18:8, or the use of Type 316, has been successful. The moly-stainless was much used by the Navy during the war because corrosion resistance was improved in salt water and electrolytic action was reduced. This addition causes stainless steel to harden much faster by any cold working processes, so that the tensile strength cannot be as high as 18:8, if bends or small ratios of wire size to spring diameters are encountered. Slightly lower stresses are advisable with this alloy because of these conditions.

Heat treatable stainless steel of the 18:8 type called Stainless W is furnished in its annealed condition (cooled from 1850 to 1950 F) and is capable of developing the mechanical properties shown in Table I.

Table I—*Mechanical Properties of Stainless W*

Condition	*Annealed*	*Aged at 950 F*	*Aged at 1000 F*	*Aged at 1050 F*
Tensile Strength	120/150000 psi.	195/225000 psi.	190/220000 psi.	170/210000 psi.
Yield Strength (0.2% offset)	75/115000 psi.	180/210000 psi.	170/210000 psi.	150/185000 psi.
Hardness Rockwell C	22/28	39/47	38/46	35/43

The steel is magnetic. Fatigue tests and the resistance to temperature investigations show that this material is not superior to hard drawn 18:8. It does offer the possibility of forming parts with smaller radii or more complicated shapes, and hardening them by a simple heating operation. Tests on Stainless Steel W show, under 100,000 psi., that a 550 F loss in load of 20% was about twice the usual loss of 18:8

material produced by cold work. At temperatures of 450 F and below, the material is satisfactory at the same stress. At 650 F, a 57% loss of load from an original 100,000 psi. in about 80 hr. was noted.

Copper Alloy Springs

Of the copper alloys used in the production of springs, phosphor bronze is perhaps one of the most useful. A newer alloy of the last ten years is beryllium copper. This alloy has many excellent properties, but is more expensive than the others. The silicon bronzes are similar to phosphor bronze in many respects and are somewhat cheaper due to the use of silicon instead of tin. All of these metals can be obtained in flat or wire form.

The mechanical spring maker uses two grades of phosphor bronze designated as Grade A and Grade C. These are outlined in A.S.T.M. B103-44 for flats, and B159-44T for wire. The Grade A is about 4½% tin and Grade C, 8%. The best physical properties are with the greater tin content. When both alloys are equally available, Grade "A" will usually be used because, unless extra strength is essential, this grade will cost less to procure per pound of useable tensile strength. Since the phosphor bronze alloys are produced by cold drawing or rolling entirely and do not respond to any heat treatment except annealing, many parts are simply formed and shipped. This practice has resulted from not realizing that, while the alloy did not respond to heat, the stresses trapped in the parts would. A stress relief of 325 to 350 F, after fabricating, will stop much so-called drift, or spring settling, and should be incorporated on important springs.

Shot blasting can be applied to phosphor bronze with excellent results. Tests show a compression spring that would only have a 20,000 to 35,000 psi. stress range under 10,000,000 cycles can easily be increased by this process to 20,000 to 50,000 psi. Phosphor bronze does not stand elevated temperatures well and should not be used over 225 F at stresses over 20,000 psi. On many electrical uses, static spring loading, and places where the loading is infrequent, phosphor bronze compression springs are stressed 50,000 to 80,000 psi., depending upon wire size. In bending, this corresponds to 100,000 to 150,000 psi.

Beryllium copper consists of about 2% beryllium in copper. A.S.T.M. Specification B120-41T gives the permissible chemical analysis and lists typical properties. Its most valuable quality is the fact that it can be formed cold in the soft state and hardened by a simple heating between 525 to 725 F. This is because the alloy has previously been quenched from 1450 F in water with the result that the copper beryllium compounds are dissolved by the copper present. At room temperature, precipitation of these insoluble materials does not occur, so the metal can be shipped dead soft or with various amounts of cold work present as in the other copper alloys. By heating, precipitation from solid solution occurs and the metal hardens to 38 to 42 Rockwell C. It is best, to make parts from as hard a sheet or wire as can be formed. Lower temperatures and less time will be required to harden and distortion due to the temperature will be minimized.

Beryllium copper is the best electrical conductor of any alloy used in springs at anywhere near its hardness. It is stronger than the other copper base spring materials and has a better fatigue resistance. It does not compare with steel in fatigue life, except under conditions where steel is corroded and copper beryllium is not; nor does it resist the combined effects of heat and stress as steel does.

Some springs are made of beryllium copper which has been cold worked to reasonable spring properties. This is miscalled pretempered material. It does not give the results that the proper heat treatment develops. The stress range, in torsion, of the alloy for 10,000,000 cycles is in the neighborhood of 25,000 psi., when not shot blasted and with stresses calculated with curvature correction. Actual results on 0.148 in. wire springs, hardened by heating one hour to 625 F, gave 10,000,000 compressions from 20,500 to 40,500 psi., when not shot peened, and 19,700 to 60,200 psi. when peened. After peening, a 400 F heating for one-half hour on springs from the same lot gave 22,400 to 78,000 psi. stress range. Higher loading caused set and a short life. It would, therefore, be possible, where long life is not a factor and springs are not peened, to go to a torsional stress of 70,000 psi., or around 85,000 psi. corrected.

Silicon bronze can be used in many applications just as well as phosphor bronze. Its corrosion resistance is about that of copper. The physical properties, as listed by the various producers, show the alloy to be but slightly lower than Grade A phosphor bronze. Specifications for wire and sheet are in the A.S.T.M. Standards. The modulus is 15,000,000 in bending, and 5,000,000 in torsion. The material can be obtained in any wire size or gage thickness from 0.003 in. up. Strain relief after forming is similar to phosphor bronze, since the material is cold drawn or rolled in a like manner. Temperatures of 350 to 375 F for stress relief will be found most useful.

The nickel silver alloys, or German silver as they are sometimes known, are alloys of copper, zinc, and nickel. The major element is copper. The nickel content runs from 30% down to 10% in the various mixtures. One of the common spring alloys is nickel 18%, zinc 25%, copper about 56%. The tensile values are between 135,000 and 150,000 psi., with a hardness of 95 to 100 Rockwell B. This material is of better quality than brass and is mostly used where its silver color is desired. It is quite corrosion resistant, but there are many alloys more resistant so that it does not have extensive use in this field.

Nickel Alloy Springs

There are four nickel alloys most used in springs; Monel, K-Monel, Inconel and Z-Nickel. Of these, K-Monel and Z-Nickel respond to heat treatment, while Monel and Inconel are strengthened by mechanical working only. All of these alloys are better resistors than the previously discussed copper alloys, and Inconel is a first class resistor. They should not

be used if high electrical conductivity is desired.

The strength of Monel metal depends on the size, whether in sheet or wire form, and ranges from 100,000 to 160,000 psi. The material makes excellent springs to resist corrosion and is often employed in mechanisms handling food products. It is slightly magnetic and its resistance to temperature and stresses are quite good, if the temperature is 400 F or less and the stress is not over 45,000 psi. in torsion (corrected for curvature) or 80,000 psi. in bending. The hardness values range from Rockwell 23 to 28 Rockwell C on spring tempers. Monel springs are heated to 575 to 650 F after forming, to stress relieve them.

K-Monel is an age-hardenable alloy and is an improvement for some uses over Monel since it is nonmagnetic. The alloy can be cold worked and then heat treated at 1000 F to have strengths of 160,000 to 180,000 psi. The alloy must be held at this temperature for at least 6 hr. and cooled slowly to 900 F at not over 15 deg. per hr. In the cold drawn condition it can be produced in spring temper and the physicals are but slightly lower. If hardened by cold drawing, parts should be stress relieved at 575 to 650 F. K-Monel will stand 500 F, when subjected to moderate stresses.

Inconel is an alloy that responds only to cold work. The tensile properties vary with material thickness from 160,000 to 180,000 psi. This material is more resistant to heat and corrosion than any other nickel alloy. At reasonable stresses, temperatures of 650 F are permissible, while recent tests have indicated the possibility of making the material go to 900 F under special conditions with some set allowed. All Inconel springs should receive a stress relief temperature of 900 F for at least one hour.

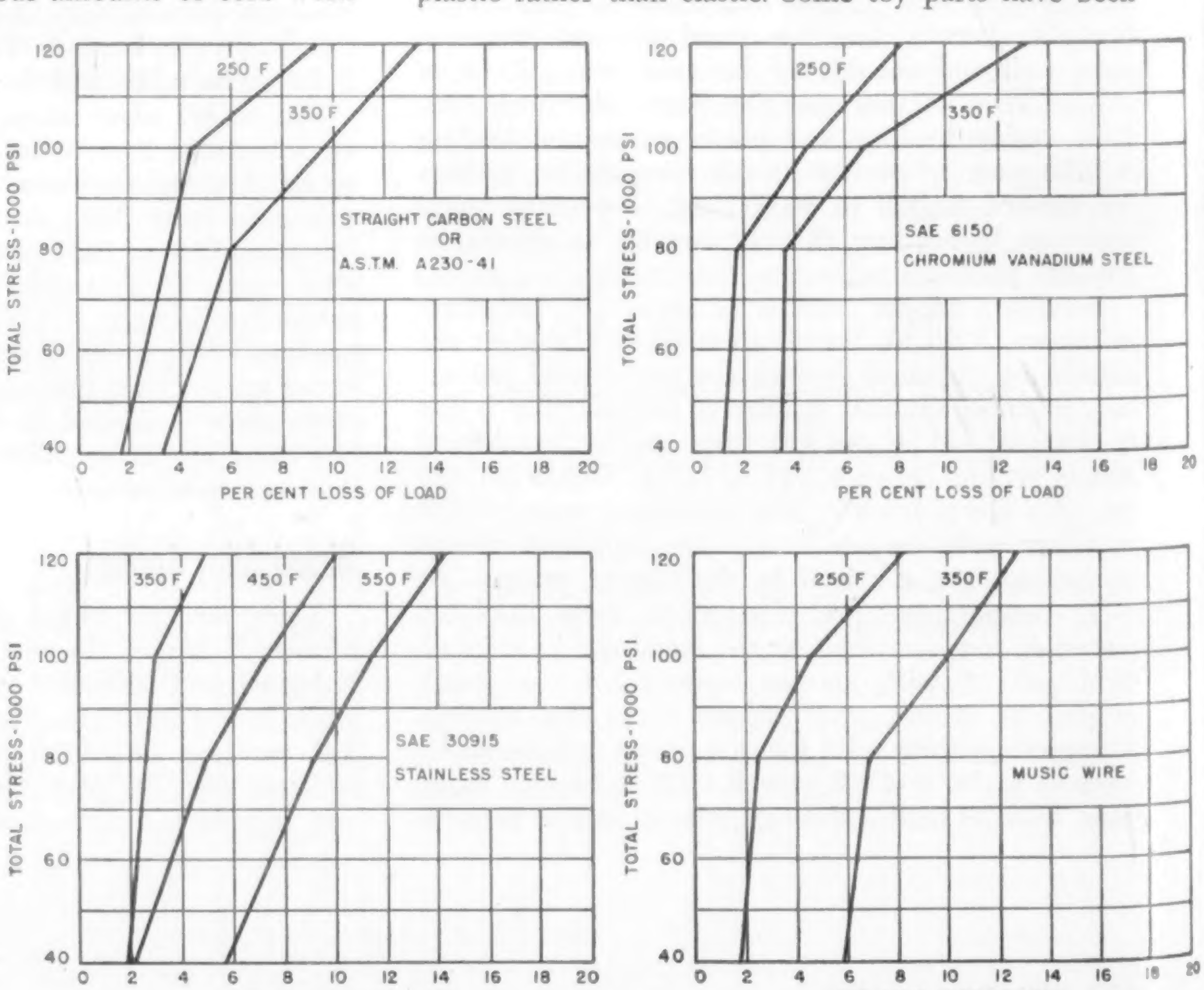
Inconel-X is a similar alloy that will respond to heat treatment. This material is given a solution treatment of approximately 2000 F before cold working and is furnished with various amounts of cold work up to 75%. A simple treatment at 1200 F for 4 hr. will harden the alloy. The use of higher temperatures for a shorter time is also satisfactory. Wire in sizes of 0.177 in. and less will have a tensile strength of at least 200,000 psi.

Z-Nickel occupies a place between K-Monel and Inconel. It can be cold worked and heat treated. After age hardening at 900 F for 4 to 8 hr. depending upon the hardness and size of the parts, its physical properties in mechanical spring sizes run from 180,000 to 240,000 psi. As drawn to spring temper, the tensile strength will run 150,000 to 200,000 psi., and it is quite useable for many springs with no heat treatment employed. Z-Nickel will stand higher stresses than Inconel, but the temperature must be less than 500 F. When the temperatures are 600 F, or more, it will not be found desirable to use this material. Z-Nickel is about as corrosion free as pure nickel and would be employed where pure nickel springs were needed.

Another of the important alloys of nickel is called Elinvar. This material is used in scale springs, hair springs, watches, bourdon tubes, tuning forks and similar installations, because of its constant modulus from -150 to +300 F. This material is austenitic and can only be hardened by cold work. The elastic limit is about 45,000 psi., and in use it is limited to stresses considerably under this. Elinvar possesses great resistance to oxidation and corrosion, is immune to magnetic effects and has very low thermal expansion. Thus, it becomes an ideal precision spring material.

For special instrument springs, glass or quartz has been employed. These will withstand corrosion from almost any media. Their elastic properties are excellent with very low hysteresis. At present their production is limited as there is a considerable degree of art in their manufacture.

The use of plastics in mechanical springs has not been great. A spring made of modern plastic is plastic rather than elastic. Some toy parts have been



These curves show the load loss of several materials at various temperatures and under varying stresses.

produced where the spring is quickly released. A plastic spring, if held long in one position, tends to assume that position and becomes useless as a spring.

On some machinery where corrosion and vibration will be encountered, wood becomes a spring material. On a beam thresher, for example, a thin hickory stick is a better spring material per dollar expended than steel and will replace the more costly metal.

Hot Formed Springs

The heavy spring industry forms all kinds of springs, whether helical, flat or volute, while the material is hot. In most hot formed springs is a hot rolled product with all the surface imperfections induced by this type of manufacture. It has a rough surface, some decarburization is always present, and seams are of frequent occurrence.

For automotive coiled springs, surface ground rods or rods cold drawn to remove surface defects are used. This process will result in material which will carry stress loads about the same as the largest of the springs made by the mechanical spring division. On rod sizes above ⅞ in., the grinding process is not employed, nor is it used on flat sections. The surface condition is the controlling factor on most all of these springs and the chemical analysis or hardness are not important in spring life. The use of alloy steel is justified only by increased hardenability, which, with a slightly higher elastic limit in the steel, will sometimes show an economic advantage.

Helical hot coiled springs are usually made so that the spring can be pressed solid. This cold working of the compression spring induces trapped stresses and will raise the yield point of the spring. When this setting is employed, the entire cross section of the bar is in plastic shear and the maximum load sustained depends upon the yield strength in shear over the entire cross section. A spring made of a shallow hardening steel will result in an elastic value diminishing from the surface to the center of the bar and this produces a spring that will carry less load when pressed solid than a spring that will harden all the way through. The use of a steel of correct hardenability, for the spring to be fabricated, is more important with large bar diameters and higher solid stresses.

Hot formed spring steels vary in stress carrying ability with the surface condition and the size of the section. For parts that are subject to maximum loading infrequently, a ¼ in. thick leaf, for example, is often stressed 120,000 to 130,000 psi., in bending, whereas its endurance limit might not be half of this amount. With helical coiled springs, stress ranges to 30,000 or 45,000 psi. can be obtained, but, if the material is pitted or has a very poor surface, much lower values must be used. When surface ground and shot peened, these springs approach mechanical springs in endurance. Thus, on front wheel suspension for automobiles, stress ranges, corrected for curvature, of 60,000 to 120,000 psi., or even 80,000 to 130,00 psi., are used.

For hot-formed springs SAE 1095 steel is one of the oldest, and even today a very popular steel. This material, used either round or flat, is, despite its popularity, one of the poorest of spring steels. The usual physical properties are tensile strength of 200,000 psi. and a yield strength of 135,000 psi. It is a shallow hardening steel, and for oil quenching the critical section is a ⅜ in. diameter bar. As a result the springs made of it have a load carrying capacity less than with alloy or other carbon steels. Because of its low cost and availability, it is found in many industries applications where other steels should actually be used.

SAE 1085 and 1090 steels are much better spring materials than 1095. Their physical properties are the same, but the average hardenability is much better. Because of the higher manganese content and a carbon content approaching eutectoid, these steels have shown greater endurance values than 1095. Their use should increase in carbon steel springs of heavy sections where the expense of alloy steel cannot be tolerated.

The most popular alloy steel for use in the heavy springs, over 1 in. bar diameter, is SAE 9260 or 9262 steel. They have a yield strength of 180,000 psi. The material can be made harder than carbon steel and still be no more brittle. The resistance to heat, especially up to 450 F greatly exceeds carbon steel. The faults of the material are its tendency to be a dirty steel, seams, and its being subject to decarburization more easily than carbon steel. As a result of these factors, the manufacture of this steel has to be carefully watched to minimize the troubles. It is used in leaf, coil, and volute springs.

Steel SAE 6150 was, before the war, employed in a number of leaf and coil springs. During the war, the shortages of vanadium and chromium practically removed it from the hot-formed field and it was replaced with silico-manganese steel which, for the use intended, was cheaper and had equivalent strength. It has an advantage over silico-manganese steel in a lesser tendency toward decarburization. In actual service, because of hot rolled surface conditions which limit the spring's life more drastically than any chemical analysis, it has shown no superior qualities to warrant any price differential.

Another series of steels being favorably considered by the heavy spring industry are the 8600 series—8650 to 8660. These steels have the same strengths as silico-manganese and a little better ductility for the same hardness. They appear to be less subject to seams, surface defects and even decarburization. At present these steels are not as available for small orders as the other steel listed.

Steels such as SAE 5150 and 4150, have been successfully used in many automotive parts, but they have not made much headway outside of this industry. The coiling of high speed steel hot for safety valve springs, where steam is preheated to high temperatures, is common.

The hot forming of nonferrous alloys is infrequent. The usual alloy considered is K-Monel or Z-Nickel which can be given good physical properties by heat treatment. Of the copper alloys, beryllium copper is the only one that can be hot formed.

Nylon, most frequently thought of as a fabric, has many important properties to recommend it as an engineering material. Here are discussed characteristics and uses of some of the most frequently used nylons.

Nylon as an Engineering Material

by EDWIN LAIRD CADY

NYLON, POPULARLY KNOWN as the most glamorized of the "glamor fabrics," actually is a plastic which is capable of thousands of prosaic industrial uses.

Nylon is not a single product but is a family of products. It can be made in hundreds of formulations each of which will have somewhat individual properties. The end products made from any formulation can be given individual properties by varying the molding and other fabricating procedures. Nylon in some forms even can be wrought and heat treated like a metal to change some of its "physicals."

Of all the possible formulations only a handful have been put on the market. Only two or three have had more than two years of industrial development, the others having been held back by the war or else being postwar developments.

In the face of this newness of the product, E. I. du Pont de Nemours & Co., Inc., the makers of nylon, are following the most conservative of policies in under-recommending rather than over selling, supplying the soundest of sales engineering but encouraging the fabricators to do materials and methods research on their own. In addition, du Pont apparently intends to sell nylon as a raw material only, doing no more fabricating in its own plants than is necessary to make possible the further processing by fabricators.

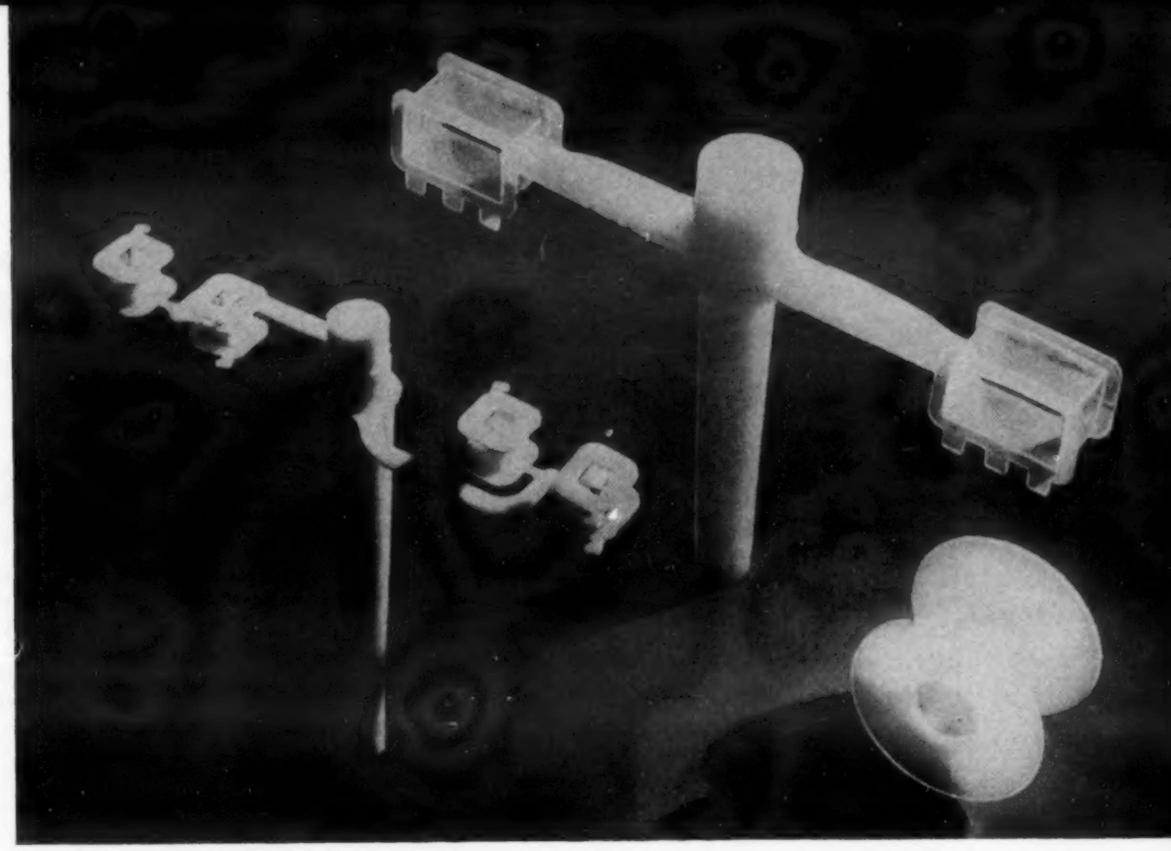
The engineer thus has a bank of technical knowledge at his disposal, some of it possessed by du Pont and the rest in the hands of nylon molders and other fabricators who have developed their own original methods and techniques. Since the rapid advances in fabricating techniques promise to be matched by the offering of new nylon formulations it may be taken for granted that for the next several years there always will be something new in nylon.

General Properties of Nylon

Aside from differences in formulations nylon products exist in the two basic categories of: 1. Moldings and others in which stretching or tensioning has *not* oriented the structural elements of the plastic in the direction of the axis; 2. Filaments, spun threads, bristles and other products in which the structural elements have been oriented in the direction of the axis.

The principal forms of nylon as a commercial material include injection molding powder, injection moldings, rods, tubes, strips, sheets, tapes (these sheets and tapes being extruded), filaments, bristles, extrusion coatings, dip coatings, coated wires and other products, extrusions, spun threads, textiles, and nylon admixed felts.

A comparison of the properties of four nylon for-



These injection molded nylon parts are spools for use in aircraft electrical instruments which must resist extremes in operating temperatures.

mulations is in Table 1. This table should be used only as a starting point for thinking about nylon. Of these four, number FM 10001 is the most commonly used injection molding formulation. Numbers FM 3601, FM 7001 and FM 3001 were originally developed as extrusion applied coatings for electric wire but have been modified for use in molding.

Chemical Resistance. A glance at Table 3 will show that FM 10001 is resistant to alcohols while FM 3601 is not so specified. How many other differences would be found on an exhaustive list of all the nylons available and soon to be available, cannot be guessed. In general the chemical resistances of FM 10001 are characteristic of the nylon family. But this factor should be checked if there is any doubt concerning specific exposures to chemical conditions.

Oxidation. All formulations of nylon will oxidize in air at temperatures below the melting point, although rate of embrittlement varies with type of nylon. Some formulations are slowly affected by concentrations of ozone such as are to be found within some electrical equipment, therefore when nylon is to be heavily exposed to nascent oxygen the effect should be investigated.

Flammability. Nylon by itself will not support combustion. But the textile products have been known to continue burning after being set afire if they had first been coated or admixed with asbestos or with anything else which would prevent droplets of molten nylon from falling away from the flame heated piece. This ability of foreign materials, even when themselves flame resistant, to impart flammability to nylon never seems to have been investigated regarding the molded or extruded products and should be checked if non flammability is of drastic importance.

Hardness. Comparisons of the resistance of nylon to indentation are found in Table 1. Variations of this property for different formulations can be had by varying the fabricating treatments. Nylon has plastic memory, tends to return to any shape from which it was deformed unless thermoset into a new shape, and therefore is not so liable to damage by permanent indentation caused by lack of hardness as would be a metal product.

Abrasion Resistance. Like "hardness," the abrasion resistance of nylon seems to be the product of several factors. Most nylons have a comparatively low coefficient of friction against many other materials, therefore does not promote its own abrasion. High resilience helps nylon to evade abrasion. Nylon appears to be extremely embeddable to abrasive particles and so not only avoids erosion but is capable of forming a protective surface made up of abrasive particles which have locked themselves into nylon matrices.

Resiliency. Nylon has at least two phases of re-

Table 1—Mechanical and Physical Factors

	Specific Gravity	Comp. Str.	Deform. Under Load at 122 F	Mod. of Elast., Psi. at 77 F	Flexural Str., Psi. at 77 F	Rockwell Hardness	Coefficient of Thermal Exp. Per Deg. F	Yield Temp. Deg. F	Flow Temp. Deg. C.
FM 10001	1.14	18,000	4.0	325,000	13,000	H 90	5.7×10^{-5}	320	250
FM 3601	1.08	No data	14.0	No data	9,900	R 111	8.0×10^{-5}	259	203
FM 7001	1.14	No data	9.7	No data	7,300	R 105	9.0×10^{-5}	327	213
FM 3001	1.09	No data	1.0	No data	8,200	M 54	8.2×10^{-5}	320	250

siliency. In the first the return to original shape after release of the deforming load is immediate. In the second, which exists if the deformation is much greater than for the first, the return is a matter of "plastic memory" or "secondary creep" and is much slower. There is evidence that this secondary phase may be divisible into phases or gradients; that there may be a degree of deformation from which recovery will be slow while a greater deformation will produce still slower recovery.

An example of the secondary phase was found in a test of lock nuts the locking members of which were nylon pieces which bore against the bolt threads. Up to the 20th applications and removals of the nuts the wrench forces needed to remove them were greater than those required for second removals of lock nuts intended for the same purposes, but nevertheless those forces steadily declined. Left off from the bolts over night, the nylon members recovered sufficiently so that when reapplied the nuts required the same wrench forces for removal as they had when brand new.

This secondary creep can be deceptive when attempting to cold-form nylon pieces as metals would be formed.

Nylon "stampings" (hydraulic pressings rather than stampings) are being made by simultaneously die pressing and thermosetting thin extruded or molded strip material, the thermosetting apparently needing long enough dwell in the dies so hydraulic operation is as rapid as any machines could apply.

Low Temperature. At temperatures below the freezing point of water various nylons gain in tensile strength and other properties but lose, as might be expected, in other physicals, as shown in Table 1. This is of great importance in products for use in high altitude airplanes, in automotive and other equipment operated in cold weather, and for a great many other industrial applications.

Table 2—Effect of Temperature on Properties

	Temp.	Tensile Str., Psi.	Elongation %	Izod Impact, Ft.-lb. per in.
FM 10001	-70 F	15,700	1.6	0.42
	77 F	10,530	54	0.94
	170 F	7,600	220	0.97
FM 3601	-70 F	13,000	No data	0.5
	77 F	7,000	280	1.4
	170 F	6,800	390	Did not break
FM 7001	-70 F	13,000	0.3	0.45
	77 F	7,450	230	3.0
	170 F	6,000	360	Did not break
FM 3001	-70 F	12,900	2.0	0.27
	77 F	7,600	75	1.34
	170 F	6,760	320	Did not break

Table 3—Chemical Resistance

	FM 10001	FM 3601	FM 3001
Resistant to	Esters Ketones Alkalies Alcohols Common solvents Weak acids	Esters Ketones Alkalies	Esters Ketones Alkalies Alcohols Common solvents Weak acids
Attacked by	Phenol Formic acid Concentrated mineral acids	Alcohols Methytenechloride Trichlorethane Trichlorethylene Formic acid Acids	Phenols Formic acid Concentrated mineral acids

Other Properties. In its other properties nylon is less individual and is more directly comparable to more commonly understood materials. For these, therefore, reference should be made directly to the tables or to the du Pont Company.

Some properties are difficult to explain. Behavior under vibrational loads is one of them. Nylon appears to have a peculiar ability to absorb some vibrational frequencies but to transmit others without adding extraneous vibrational characteristics of its own.

In gears and bearings, for example, molded nylon definitely dampens vibrations but to an extent which does not seem to have been measured excepting as the actual results have been observed in machines in which nylon is used. In the knees of phonograph needles, by contrast, nylon transmits vibrations with high fidelity and without adding extraneous ones of its own. In both cases deflection of the nylon under applied load seems to be a more decisive factor than inter-crystalline absorption of vibrations, the dampening occurring when the vibration is forceful enough to cause mild deflection as in gear teeth.

Molding, Forming, Machining

Nylon Moldings. More formulations appear to have been developed for molding than for other nylon fabricating methods. A brief description of some of these appears in Table 5.

Some nylons melt at higher temperatures than are common for thermosetting plastics.These have a sharp melting point and an extremely narrow mushy or "plastic" range. Although often recommended to be molded in its liquid range, most of the molders who make high accuracy products hold it within the narrow plastic range and require unusually well controlled injection equipment to do so.

For molding to high accuracies the molder requires knowledge of the shrink characteristics of the ejected moldings. Nylon moldings as they shrink obey the same laws as to differences of sectional thicknesses as do metals, but without the segregation problems of a metal, and also without the benefits (or penalties) of the high thermal conductance of a metal.

Nylon moldings are purchased direct from the molders, many having closely guarded individual techniques.

Molding Tolerances. Ordinary tolerances of nylon molding are to the order of 0.0015 in. per dimensional inch, but 0.0005 in. per in. have been held when necessary. As in any process which depends upon predictable shrinkages of cooling, an extremely close tolerance is easier to hold on one dimension of a part if wider tolerances are allowed on other dimensions. Strategems such as restraining the shrinking on one dimension for high accuracy while letting it go at random on others either have not been found practical or else have not been released for publication.

Sections as thin as 0.007 in. have been molded to lengths of 1.0 in. and widths of 0.050 in. and in flat planes. In much smaller pieces the extremely thin sections needed for hypodermic needles can be molded.

Machining and Fabricating Solid Stock. Nylon solid stock has the general machinability of semi-hard brass. It has high coefficient of thermal expansion, low thermal conduction, therefore tends to expand out of true dimension if too heavy cuts are taken. Machining methods call for sharp edged tools with edges kept sharp lest the somewhat fibrous material be given a rough surface; the highest available cutting speeds; with cuts to depths of not over 0.007 in.; and plenty of cutting oil to keep down the heat. (For FM-10001 oil is frequently unnecessary.)

Grinding is done with loose meshed wheels. The wheels tend to load up and must be dressed to fresh surfaces, but otherwise do not seem to wear. Plenty of coolant should be used.

Glueing. One of the most valued properties of nylon is that it does not tend to stick to anything else. But nylon sections can be cemented to nylon sections or to other materials. Cements found successful to date are Durez Compound number 12041, and Chrysler Cycle Weld number C-5. There may be others in successful use; the adhesive makers should be consulted. The natural solvents of nylon, such as molten phenol, or concentrated formic acid, can be used to soften the nylon surface and cause it to adhere but this is not generally recommended since it requires extremely close control measures.

Applications and Forms

Faucet Washers. Molded of formulation FM 10001 these are said to have outlasted any other washers ever tested. But since this formulation is believed to be harder than would be applicable to some badly worn faucets a softer one is being tried, and with the same excellent test reports.

Hammer Faces. Nylon faces on hammers showed superior endurance and resilience on several tests. They may be machined from rod or bar stock, or may be molded from a special formulation, the more common FM 10001 being considered too hard and brittle by some of the hammer makers.

Grommets. Grommets which hold electrical cords against strains sufficient to break the cords are molded of nylon and used on domestic appliances to prevent pulling the cord loose from the appliance. These grommets have been tested successfully at 400 F but are recommended at 212 F. Counterparts of them could be used to hold various cables and other devices of industry; the grommet holds after merely being assembled on the cable and then pushed through a simple punched hole into which it locks. But markets other than domestic appliances do not seem to have been explored.

Medical Appliances. Nylons will withstand most of the temperatures used in medical practices, do not corrode, do not oxidize, can be sterilized without discoloration, do not freeze to other parts, have other advantages which lead to wide useage as parts of medical appliances.

Gears, Bearings, Other Machine Parts. Nylon surfaces have low coefficients of friction against hard materials, will withstand any temperature rises which are safe for ordinary lubricants, can be lubricated with water or with almost any light oil, are vibration absorbent, are embeddable to abrasive products.

Nylon also is lower in compressive strength than some products of which machine products ordinarily are made. On a pressure-temperature-velocity (PTV) curve for bearings, therefore, nylon would rate somewhat low on permissible pressures per square inch of projected area, as high as any but the "high temperature" bearing materials on permissible operating temperature, and high enough so the limit has not yet been experimentally found on permissible velocity. Thermal expansion is a factor to be considered in replacing metal bearings with nylon.

On one bearings-use test the shaft was deliberately roughened to the point where it would wear out an ordinary bronze bearing in a few hours. This same shaft ran in nylon (at high speed but light load) for several days and the only apparent effect was to polish off the worst of the roughness, the nylon being unaffected.

Nylon gear trains under light loads but high speeds were tested under conditions of high speeds with light loads but with silica dusts constantly impinging upon them. Tested similarly, brass gears failed in a few

Shown here are a number of molded nylon parts used in another type of aircraft instrument. The material has toughness, resists fungus and can be molded into complex shapes.

hours. Nylon gears ran for 18,000 hr., and when taken down, were found to have so embedded the surfaces of the teeth with silica dust that they were running silica to silica and might have lasted indefinitely so long as a constant supply of fresh silica was available to replace any that became dislodged from the surfaces.

Nylon gears at high speeds were found to run noiselessly and vibration free with 0.0001 in. more back lash than was permissible for steel gears.

Nylon friction disks or pulleys driven by rubber wheels showed higher coefficient of friction against the rubber than did metal pulleys, and also outlasted the metal. The coefficients of friction of nylon against various other materials have been very little investigated, especially at varying speeds and impingement pressures.

Nylon is somewhat static-prone, and will not conduct away any generated static electricity as will metal machine parts. But nylon also is a good insulator.

Where nylon machine parts are subjected to high friction with pressure, designs sometimes are successful if the nylon member is made as thin as practical and the remainder of the part is a metal of high thermal conductance.

Nylon gears, bearings and other machine parts commonly are injection molded if wanted in sufficiently large quantities. But they also may be machined from rods or tubes, etc., and by procedures which any shop will find simple. Nylon gears and brass gears have simultaneously been generated on the same machine and with the same tools.

Other Molded Products. Aside from novelties, nylon molded products include hundreds of such items as seal rings for cameras, bobbins for spinning, top bearings (they need no oil) for roving frames, instrument cams, zipper parts.

Rods, Sheets, Tubes. Nylon rods in diameters from 0.125 in. to 2.25 in., lengths up to 8 ft. (longer if specially ordered) are carried in stock by the Polymer Corp., at Reading, Pa. Formulations include FM 10001 and FM 3001. All rods are centerless ground to plus or minus 0.002 in. limits but could be held to plus or minus 0.001 in. on special order. Size diameters in stock increases by 0.125 in. increments.

Tubing, so far, has been made only in short lengths and on special order. One size was 6 in. I.D. x 0.50 in. wall x 12 in. long, used as bushings on a barrel plater. Another was 2 in. I.D. and 4 in. long. Longer lengths are under experiment.

Strip can be supplied to 2 in. wide, but 8 in. to 10 in. widths can be expected in the near future. Thicknesses are from 0.002 in. to 0.060 in. The wider widths will be known as sheet.

Coatings. Nylon coatings can be applied by extrusion, and by bath methods. The baths require extremely close control of temperatures, viscosities and solvent ratios, but electric wires now are passing through extrusion machines at mile a minute speeds. Like so many other applications of nylon this coating business is scarcely in its infancy.

Felts. Nylon alone has not successfully been felted but can be admixed up to 25% and possibly to 35% with wool or cotton or other feltable fibers. The nylon admixture adds strength, capillary action (nylon is extremely wettable by oils or water), abrasion endurance, heat resistance, persistence of resilience and of other physical properties. One present use is in filters.

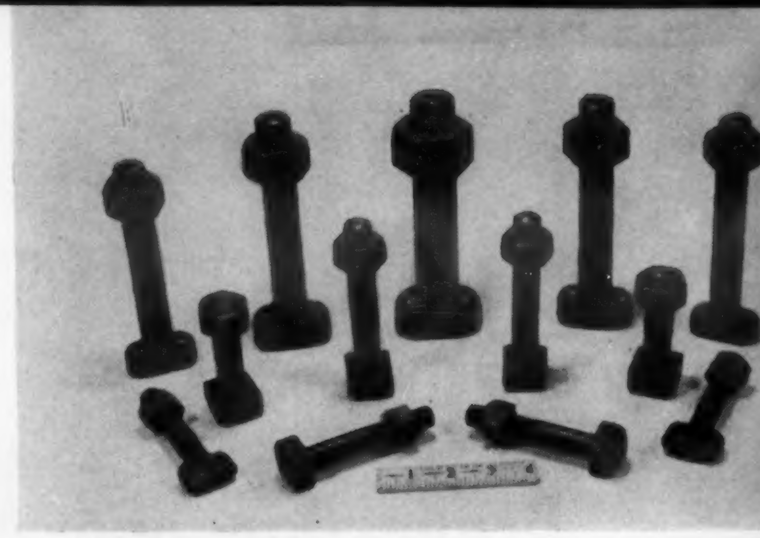
Nylon in its various forms is capable of solving thousands of industrial problems. But it rarely can be tossed in as a replacement of something else without critical consideration of its properties. In the two years that nylon has been on the general industrial market a wealth of direct experience and of experimental knowledge has been built up by its maker and its fabricators. Expansion of its applications may be predicted to be rapid. The engineer contemplating its use for the first time should consult with producers of the materials, but may need to make careful selection of the fabricator which is to work on his problems.

Table 4—Results of Exposure to Light, Weather and Water

	Basic Color	Effect of Acc. Weathering	Outdoor Exposure	Water Absorption, %
FM 10001	Light Cream	Slight Discoloration	Slight Discoloration	1.5
FM 3601	Light Straw	Very slight Discoloration	No data	0.53
FM 7001	Light Amber	Discolors	No data	0.67
FM 3001	Trans. Cream	Good	No data	0.44

Table 5—Nylon Molding Powder

Type	Outstanding Properties
FM 3001	Semi-rigid, excellent heat and chemical resistance; toughness.
FM 3003	Heat-stabilized. Particularly adaptable for magnet wire covering. Not colored.
FM 3601	Good resistance to heat, abrasion, gasoline, and lubricating oils. Lies in properties between FM 3001 and FM 6001. Has good flexibility.
FM 3604	Properties lie between FM 3001 and FM 6001. A heat stabilized nylon used especially for wire coating.
FM 6001	Flexibility; resistance to heat, abrasion, gasoline, and lubricating oils; toughness.
FM 6003	Similar to FM 6003 (Vacuum dried FM 6001).
FM 6501	Flexibility; resistance to heat, abrasion, gasoline, and lubricating oils; toughness. Slightly more flexible than FM 6001.
FM 6503	Similar to FM 6501 (Vacuum dried FM 6501).
FM 7001	Toughness, abrasion resistance. Can be extruded on wire. Fairly flexible. Can be injection molded.
FM 8001	A flexible nylon. This is still experimental and is not for general sale.



Shown here are a few standard types of cast austenitic malleable bolts.

Austenitic Malleable Iron

—A New Ferrous Material

by C. K. DONOHO, *Chief Metallurgist, American Cast Iron Pipe Co.*

CAST AUSTENITIC STEELS as well as austenitic cast irons are well known and useful members of the foundry metals. A new type of cast ferrous metal, an austenitic malleable, was developed and put into commercial production at the American Cast Iron Pipe Co. during 1946. This material combines the useful qualities of good mechanical properties, machineability, and a high degree of corrosion resistance. The parts at present commercially produced of this metal are corrosion resistant cast bolts for pipe joints.

The molten metal is produced in a cupola furnace to the following desired composition:

Tot. C	*Si*	*Mn*	*P*	*S*	*Ni*	*Cu*	*Cr*
2.30	2.00	1.25	0.10 Max	0.12 Max	15.0	6.0	3.0

This is compositionally a modified Type I Ni Resist cast iron, the unique feature of this material being the processing to give a malleable rather than a gray iron structure with the attendant advantages of significantly higher strength and ductility.

The molten metal from the cupola mixing ladle is cast to shape in two-part cast iron molds mounted on a revolving turn-table. The chilling action of the metal mold causes this iron to cast "all white"—that is, with no free carbon—in sections up to 1½ in. Annealing the hard, brittle, as-cast parts at 1800 F for 2 hr. decomposes most of the combined carbon to give a soft, tough "malleable" structure with a matrix substantially austenitic. The heat treated castings are readily machined in standard production bolt threading machines.

A modified Ni Resist cast iron composition is so processed as to provide a malleable rather than a gray iron structure. This results in a corrosion resistant material with good strength and ductility.

This material has a tensile strength of about 70,000 psi., yield strength of about 50,000 psi., elongation in the order of 5%, and Brinell hardness of 180 to 200. These properties may be compared with a tensile strength of about 30,000 psi. and less than 1% elongation for the usual sand cast austenitic irons. The excellent corrosion resistance of the Ni Resist compositions is well known and proved over years of service. Accelerated corrosion tests made to date indicate that the denser malleablized austenitic iron is at least equal and probably superior to comparable austenitic gray irons in corrosion resistance.

Acipco Ni Resist bolts for cast iron pipe joints are made of the material described and have been commercially produced by the hundreds of thousands since the development of the process. These austenitic malleable bolts are now specified for services where previously only the more expensive bronze or stainless steel bolts were permitted, that is, where highly corrosive conditions exist and where a high degree of toughness and ductility is required.

Although, at present, the only commercial application for the austenitic malleable metal is in the cast bolts for pipe joints, the combination of strength, ductility, machineability, and corrosion resistance in a castable, cupola melted metal promises many other useful applications to be developed in the future.

Properties and Applications of Molybdenum

by J. GELOK, *Manager, Lamp and Electronic Tube Parts Sales Dept. Westinghouse Electric Corp.*

LONG IMPORTANT in the incandescent lamp industry, molybdenum is becoming increasingly vital in the glass and other industries. Its high melting point—2620C (4750 F)—along with many outstanding properties promise that in the future it may become a leading contender in such varied applications as:

1. Heating elements for ultra-high temperature electric furnaces without element protection.
2. Blades, nozzles and firing chambers for ultra-high temperature gas turbines and rockets.
3. Dies for die-casting brass or other alloys, melting at relatively high temperatures.
4. Hot and cold metal working tools of good stability and long life.
5. Liners for tanks, vessels and pipes where corrosion properties are a factor.
6. Seamless tubing and valves for the petroleum and chemical industry.
7. Crucibles for melting materials of very high melting points.
8. High temperature resisting barriers.
9. Construction material for use at elevated temperatures.
10. Dies for hot pressing drawing and extrusion.

Pure molybdenum was first developed for use in the incandescent lamp industry and still finds wide use in that field. Molybdenum wire is used to support the tungsten filament in the lamp because of its high melting point and relative economy and ease of working as compared to tungsten. The modern "coiled-coil" tungsten filament as used in the incandescent lamp and fluorescent lamp is wound on a molybdenum mandrel which is later dissolved out. The electronic tube industry also uses large quantities of molybdenum wire rod and sheet. Grid windings, supports, leads and springs subjected to high tube temperature are made from the wire, while plates, channels, caps, and other special shapes are formed from molybdenum sheet or machined from slab material.

The many admirable properties of molybdenum have been recognized for some time, but use of the material was limited due to size and other limitations. Now means have been developed whereby it is produced in forms of sufficient size to be used commercially.

The glass industry today is one of the largest users of heavy molybdenum sheet of plates and this use is continually expanding as more and more electric glass-melting furnaces used for special glasses are installed or converted from carbon electrodes to molybdenum. Large molybdenum electrodes are built up from several pieces of heavy plates and serve to conduct the current through the molten glass. It is possible to obtain much higher temperatures and more uniform temperatures by this method of heating. The resulting product from glass furnaces using these new electrodes is reported to be of better quality than that previously obtained.

Molybdenum in the form of wire rods or strip is also used for heating elements in the construction of high-temperature furnaces capable of operating at temperatures of 1650 C (3000 F) in vacuum or protective atmospheres. Furnaces of this construction are quite economical and have considerable life. Spot-welder tips made from molybdenum take advantage of the high electrical and thermal conductivity of the metal as well as its high-hot hardness and good contact properties.

Molybdenum has also been used to advantage to make bi-metals, thermocouples, stirring devices and thermocouple protection tubes—all for use at temperatures above the melting point of the common metals.

Recent improvements in technique make possible the production of molybdenum in sizes sufficiently large to make this material available for a number of uses.

For the past several years, Westinghouse has carried out extensive investigations on alloys of molybdenum in order to produce a product with superior oxidation resistance, higher strength and other desirable properties. Many of these alloys are still classified as "secret" but at least one of the alloys has found wide acceptance in the industrial field. This alloy, known as "M2A" was found to have many advantages over standard molybdenum, having greater strength and ductility as well as increased resistance to heat checking.

Another distinct advantage of this new alloy is its better resistance to shock both hot and cold as compared to pure molybdenum. Using the Charpy impact test at room temperature results have indicated this alloy to be about 825% stronger. This material has slightly lower electrical and heat conductivity and requires higher annealing temperatures. The results on some of the tests made show that this alloy was far superior to pure molybdenum as a spot-welding tip, especially as regards the number of welds that could be made between tip dressings.

Powder Metallurgy Processing

Molybdenum alloys with a hardness of 60 to 65 Rockwell C have also been prepared and tested for applications where high hardness is essential. These alloys are as hard at high temperatures as many of the common "hard" alloys are at room temperatures.

Combinations such as molybdenum-silver and molybdenum-copper also find wide use as electrical contacts. These are not true alloys but the contact combines the high temperature resistance of the molybdenum with the high current carrying capacity of the silver or copper to produce a superior contact.

Molybdenum is one of the heavy metals of the class of tungsten and tantalum, characterized by very high melting points. The pure metal is silvery white in color with a specific gravity of 10.3 and a melting point of 2620 C (4750 F).

The high melting point of molybdenum makes it impossible to use the ordinary methods of reduction, melting, casting and working which are employed by the steel industry and it is necessary to employ the technique of powder metallurgy. This method, in the case of molybdenum, involves pressing the metal powder in steel dies at a pressure of approximately. 40,000 psi., sintering the resulting bars in a hydrogen atmosphere at very high temperatures by passing electric current through them, breaking down the sintered bars at high temperatures by rolling, forging or swaging and finally working to the required size and shape at lower temperatures.

The metal powder used in this process must be of the highest purity obtainable as even very small amounts of impurities would seriously effect the operation of the electronic tube or incandescent lamp. Molybdenum produced by Westinghouse is guaranteed to be more than 99.9% pure. The metal powder is usually produced by the reduction of very pure molybdenum oxide or ammonium molybdate in hy-

drogen gas. The resulting powder is microscopic in size; the average diameter of the individual particle being approximately one to two microns, or 0.00004 to 0.00008 in.

The production of molybdenum products has been limited in the past by the size and shape of the ingot which could be pressed and sintered. For many years the largest ingots used commercially were ¼-in. square and about 10-in. in length. This size was gradually increased to a point where at the beginning of World War II, ingots approximately 1-⅛ in. square and 20-in. long were being produced commercially. The largest item that could possibly be made from these ingots in one piece was of course limited to the weight of the starting ingot, or approximately 8 to 10 lb.

In considering the very outstanding properties of this metal many new uses were developed during the war, as well as many potential uses. However it developed that a good number of these uses would require the manufacture of much larger pieces than had ever been attempted in the past. By the use of new manufacturing methods and techniques developed at the Westinghouse Lamp Division it was found possible to remove the previous limitations on size and shape of ingots so that ingots weighing as much as 250 lb. could be produced. Methods were also developed for making shapes other than the heretofore standard rectangular ingot. Solid cylinders, tubes, disks, squares and other shapes have been produced in diameters up to 7-in. and in lengths up to 30-in. These large ingots also permit the manufacture of molybdenum sheets in sizes heretofore unknown; sheets 20-in. in width and 36-in. long have been produced. However it is known that wider and longer sheets could be produced today with the installation of larger rolling and fabricating equipment.

Properties

The properties of molybdenum are outstanding and make an imposing list of physical and electrical characteristics. Its melting point, modulus of elasticity, strength at elevated temperatures and thermal conductivity are generally higher than any steel. It is lower than steel in specific heat and coefficient of expansion and its corrosion resistance compares favorably in many media with tantalum, palladium and platinum, each considerably more expensive than molybdenum.

While tungsten is slightly superior to molybdenum in some respects, its cost is higher, about twice as heavy and it is limited in the sizes and forms obtainable.

Melting Point: Of all the elements, the melting point of molybdenum is exceeded only by those of carbon, tungsten, osmium, rhenium and tantalum. This high melting point permits the use of molybdenum at temperatures for above the softening point of common metals or refractories.

Specific Heat: Molybdenum has a low specific heat —about half that of nickel or steel. Low specific heat is of advantage where rapid temperature changes are desired or for the reduction of temperature gradients in a heated body.

Thermal Conductivity: The high thermal conductivity of molybdenum—about three times that of steel—is an advantage when the material is to be used for heat transfer. Because of its high thermal conductivity and low specific heat, molybdenum can be rapidly heated and cooled with much lower thermal gradients than for steel. Molybdenum when used for welding tips takes advantage of this property together with high-hot hardness and good contact properties.

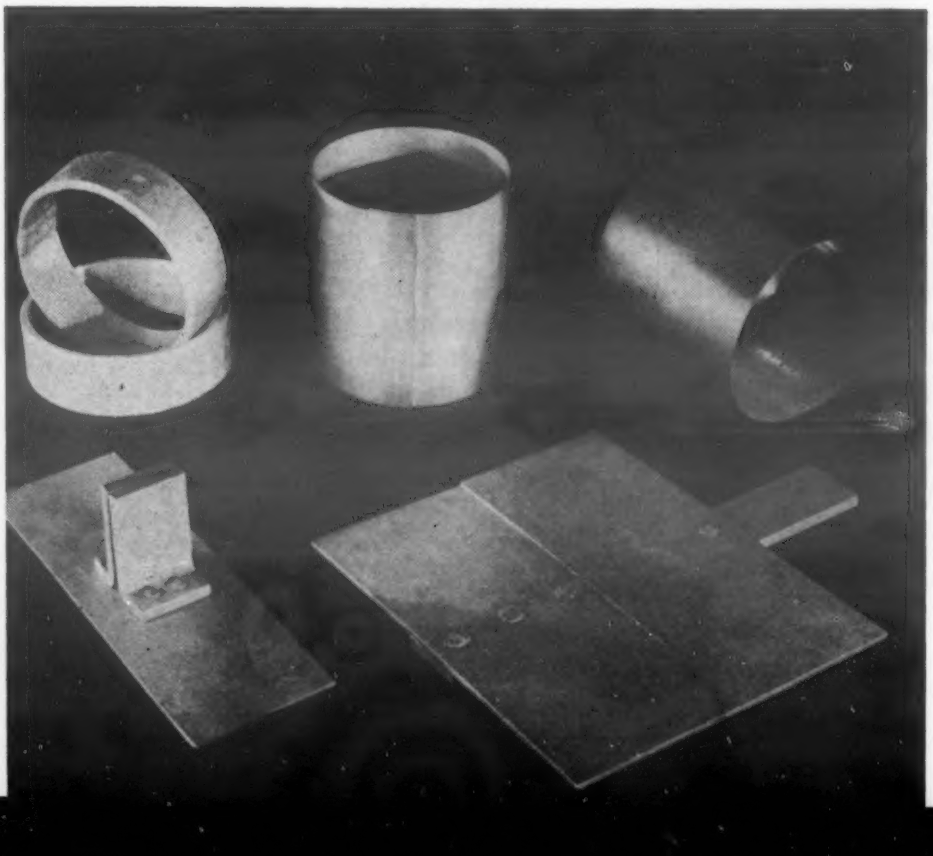
Electrical Conductivity: Molybdenum has an electrical conductivity about one-third that of copper and silver; among the common metals it is excelled in this property only by aluminum, copper, gold, magnesium and silver. This property is important where mechanical parts carry current.

Thermal Expansion: The low coefficient of thermal expansion of molybdenum (half that of steel) is advantageous in any constructional application where elevated temperature is involved. This is particularly true for non-uniform temperatures or applications involving intermittent heating and cooling as the low coefficient means greater dimensional stability and less danger from thermally-induced stresses. Special glasses are available for sealing to molybdenum, whose low coefficient of expansion is about the same as that of Kovar. The higher thermal and electrical conductivity of molybdenum are distinct advantages in some sealing applications and make possible the use of smaller wire.

Tensile Properties at Room Temperature: Molybdenum sheet has tensile strengths of from 70,000 to 140,000 psi. depending upon the amount of "cold" rolling used in fabrications. On molybdenum wire, tensile strength varies from 100,000 to 150,000 psi. but values as high as 350,000 psi. have been obtained with cold-drawn wire. Tensile properties in cold-worked sheet and plate material can be appreciably different in the direction of rolling as compared with that transverse to rolling direction.

High Temperature Properties: The strength of molybdenum in the very highest temperature brackets

These forms and shapes show to what extent molybdenum can be fabricated without difficulty.



(1650 F) definitely far exceeds that of any other commercial metal or alloy except tungsten.

Magnetic Properties: Molybdenum is paramagnetic at room temperature. For practical purposes, it is "non-magnetic" and magnetically similar to 18:8 stainless steel and aluminum.

Modulus of Elasticity: The high modulus of elasticity of molybdenum is exceeded only by those of sintered carbides, iridium, and tungsten. The metal is, therefore, well suited to applications requiring high rigidity. A combination of high modulus and high tensile and yield strengths means that a particular part can be made smaller and still react the same to a particular stress value. However the high modulus of elasticity partially offsets the beneficial effect of a low coefficient of expansion on stress resulting from thermal gradients. In cold-worked sheet or plate material modulus of elasticity varies with the direction and amount of "cold" work.

Corrosion Resistance: The corrosion resistance of molybdenum is high, showing no reaction with cold or warm hydrofluric acid, dilute sulfuric acid, cold potassium hydroxide, phosphorus, or sulfur and its compounds. Reaction is slow with concentrated hydrochloric acid and concentrated nitric acid. Reaction is rapid in hot dilute hydrochloric acid, dilute nitric acid and in hot concentrated sulfuric acid. In molten oxidizing salts the reaction is violent.

Hardness: Molybdenum has a room-temperature hardness of approximately 85 to 90 Rockwell B or 165 to 185 Brinell. The hardness has been measured at temperatures from 180 C to 1900 C (292 F to 3450 F). A continuous decrease in hardness with increasing temperature was found with a sharp increase in hardness at low temperatures.

Oxidation Resistance: The metal molybdenum oxidizes slowly at about 400 C (750 F) and forms a dense white smoke at about 700 C (1292 F). The high temperature use of molybdenum, therefore, depends on the application of vacuum, protective coatings, or a protective atmosphere. Two oxides, MoO_2 and MoO_3 form on heating molybdenum in air; the latter is the predominant oxide and controls the rate of oxidation. MoO_3 is a volatile oxide with a melting point of 795 C (1463 F) and thus affords no protection to the underlying metal at higher temperatures.

Working Characteristics

Machinability: For years it was found that this metal was very difficult to machine and that all machine work required special tools and extreme care. With the development of the new process we find molybdenum now being produced to be readily machinable. Ordinary high speed steel tools are commonly used in conjunction with lubricants such as cardon tetrachloride or white lead. Although molybdenum is not a hard metal, it is "tough" and abrasive. It is essential, on all machining, that the tools be kept sharp, clean, and cool—especially in drilling, where the difference in expansions of the tool and molybdenum are apt to cause sticking. The depth of cut should be great enough to get under the surface of the

Molybdenum now being produced can be machined with ordinary high-speed steel tools. Likewise, it can be welded if proper caution is exercised.

metal in order to prevent "glazing" of the surface and dulling of the tool. If a highly polished surface is desired, similar to that resulting from the best chromium plated product, it can be obtained by the use of standard buffing wheels, and will be one of a reasonably lasting quality.

Spinning or Forming: Molybdenum metal sheet can be spun or formed by deep-drawing. In spinning thicknesses of metal up to 0.032 in., a small gas flame is usually played on the material during the operation to raise the temperature of the metal to 100 to 300 C, depending on the thickness and the shape of the spun item. Success can be obtained on deep drawing and forming material cold under 0.030 in. in thickness. However on heavier material it is advisable to use some heat. The amount of heat necessary will depend on the thickness of the molybdenum as well as the type of forming to be accomplished.

Welding: Molybdenum can be successfully welded to molybdenum and to numerous other materials. It is necessary to take certain precautions in order to obtain a ductile weld. Extremely short heating times should be used in order to prevent grain growth and consequent brittle welds. For welding thin sheets or wires a condenser-discharge type of welder or ignitron type with ½-cycle timer is satisfactory. Molybdenum or molybdenum alloy tips are preferable. It is desirable to sandblast or dimple at least one surface. For heavy sheets and rods the most satisfactory weld can be made using the atomic-hydrogen arc or helium shielded arc.

Riveting: It is also possible to join molybdenum by the use of molybdenum rivets made from wire or rod. Small rivets having a shank diameter of about 0.0625 in. can be manufactured by the standard rivet process from annealed molybdenum wire supplied to the fabricator in coil form. Large rivets are turned in a lathe from rod stock. The head of large rivets can be formed by heating the end of the rivet and peening with a hammer.

Despite all of the precautions which might be taken as to alloy compositions, time in the furnace and temperatures, aluminum alloy parts can be ruined by two simple oversights in heat treating.

Improving the Quality of Heat Treated Aluminum Alloy Parts

by Davidlee V. Ludwig, *Consulting Materials Engineer*

OF THE MANY FACTORS which control the quality of aluminum alloys, two are commonly overlooked even in plants ostensibly using the most modern controls. It is fairly well recognized that the composition of the alloys must be held within specification limits if response to heat treatment is to be satisfactory. It is becoming more widely known that the method of melting the metal, both in the refining and alloying stage as well as in the foundry or forge, is of critical importance. The effects of carbides and nitrides of aluminum and numerous of its alloying constituents are being increasingly publicized and the techniques of control for them are known. Deoxidizing and degassing fluxes of many acceptable formulas are used. However all factors of control can be completely negated during two of the simplest stages of processing—loading the charge preparatory to solution treatment and quenching it subsequently.

The field of application of heat treated aluminum alloys is continually growing. During the war nearly 90% of all aluminum was applied in heat treated condition. Contrary to many prognostications, there has not been a precipitate decline in the total tonnage of heat treated metal, but rather the tendency has been to retain the level reached during the war. In other words, more and more applications are being found for high strength aluminum alloys for everyday products. It is therefore increasingly important that these materials be handled by techniques which will result in reliable and durable performance. Many applications in war were intended for short service; too frequently this led to skimping on control standards when knowledge that the total life expectancy of the finished product could not exceed a few weeks or months. Now applications must be engineered for years of safe service, correct handling is an increasing obligation.

The past ten years have seen the presentation of most of the accepted practices currently applied in the thermal treatment of metals, particularly of aluminum alloys. Furnace designs have become superior. Quenching machinery has become more reliable. The effects of atmosphere constituents upon various aluminum alloys have been publicized widely. The best equipment fails if improperly used however, and false economy on one hand coupled with carelessness on the other can result in the production of aluminum of questionable value. The economic aspect is involved when a heat treater attempts to charge a furnace with three or four times its designed capacity.

Fig. 1—Overloading of cast and forged aluminum parts in the heat treating furnace is often the cause of poor heat treating results. This is an example of poor loading technique. (All photographs courtesy Gehnrich & Gehnrich)

This is the first common fault in heat treating aluminum. With such practice several things are inevitable. Many of the castings will be badly warped. Expensive straightening is thereby entailed. The mechanical properties of castings which are severely cold straightened is usually poor and their dimensional stability usually is not satisfactory due to the subsequent relaxation of stresses imparted to the metal in straightening.

Of more importance however is the fact that the heat penetration of such a densely packed charge is almost completely dependent upon metal to metal conduction, as convection currents are stopped. This means that the castings in the center of the charge reach heat so slowly, if at all, as to fail to have time to undergo the total re-solution of constituents intended by the high temperature long time solution treatment commonly given castings and forgings. They therefore cannot respond to precipitation hardening, even if effectively quenched. However the dense packing precludes the correct quenching of the charge.

The second common mistake in heat treating aluminum is that of slowness in the quenching operation. Although most specifications permit a maximum time of 30 sec. to elapse between the opening of the oven and the complete submersion of the charge in the quench water, insufficient attention has been placed upon the importance of the utmost speed in quenching, with the result that in too many plants minutes sometimes elapse. There is no reason why a maximum quench cycle of 15 sec. cannot be attained, regardless of the weight of charge or size of furnace, if proper provision for quick handling has been provided. In one installation designed 4 to 6 tons of castings were handled in production and were quenched in an average time of 10 sec., frequently in as little time as 7 sec. As a result the physical properties of metal otherwise correctly handled were superior. It was common to attain 42,000 psi. for 195T6 and 40,500 with 7% elongation for 356T6 aluminum alloys.

Effects Similar

The effects of slow quenching or improper loading are substantially the same. In the extreme case shown in Fig. 1 the castings in the center of the charge will show little or no response to heat treatment. Regardless of the time they are aged in the precipitation treatment, their structure will remain metallographically speaking totally unaffected. The hardening constituents will be spaced in the same manner as in as-cast structures, or in the case of forgings in as-wrought or fully annealed condition. The hardness of the metal will be the same as for the as-cast metal, and frequently will be softer than the as-forged, work hardened metal was before treatment. At best, slight annealing is attained, but no solution of hardeners. Depending upon the length of time lost in quenching, the relative thickness of the castings or forgings, and the movement of air around the charge, the structure of improperly quenched metal can be the same as that of the castings held in the center of a poorly spaced charge. Fig. 3 presents curves determined from tests made on sand cast aluminum 195 alloy solution treated, quenched at varying controlled times, and aged for 3 hr. at 320 F. It is important to observe several facts shown in this family of curves.

First, though the properties of the metal quenched

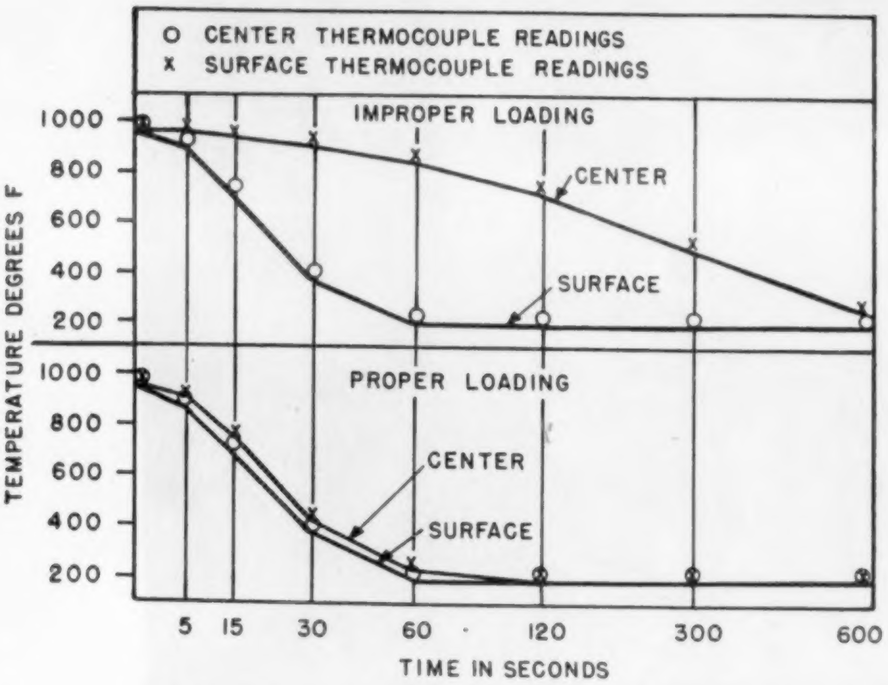


Fig. 2—Data upon which these charts are based were produced through comparing properly and improperly loaded charges of aluminum alloy castings quenched in boiling water from 970 F. From the curves, it is obvious why many parts in the center of a large charge would not attain proper temperatures.

at exactly 30 sec. interval are slightly in excess of specifications, they are far from the potential strength of the alloy as indicated by the figures obtained for more rapid quenching. Secondly, the bars definitely fail in tensile strength and elongation after a lapse of 45 sec. Bear in mind that the conditions of the test were a little more extreme than would be true of a larger mass of metal, as for instance in a charge of several tons of castings in which the surface area of the charge would be proportionally much less than on a single pair of tensile bars. Conversely, however, in respect to the cooling curves of thin sections, spinnings, light castings and forgings, the curves would obviously shift slightly to the left. After the lapse of 2 min. the properties are substantially those of as-cast metal, in these particular tests. Comparison of the data in Fig. 2 and 3 evidence the close similarity of results which obtain in packing and slow quenching. From the surface to the center of a densely loaded charge of castings, all properties obtained in the work shown in Fig. 3 would be found to decrease as the distance from the surface of the charge increased.

Frequently a heat treater argues that it is good to load his castings as tightly as possible to overcome the losses of heat inevitable during transfer from furnace to quench. The logic of this argument is such that argumentation is valueless. Usually the practice is found where inadequate provision for quenching exists. The heat treating foreman has found, through a peculiar process of reasoning, that with a tightly packed charge he can take his time about quenching and test bars properly placed in the charge, not too close to the surface, not too far inside, will pass specifications.

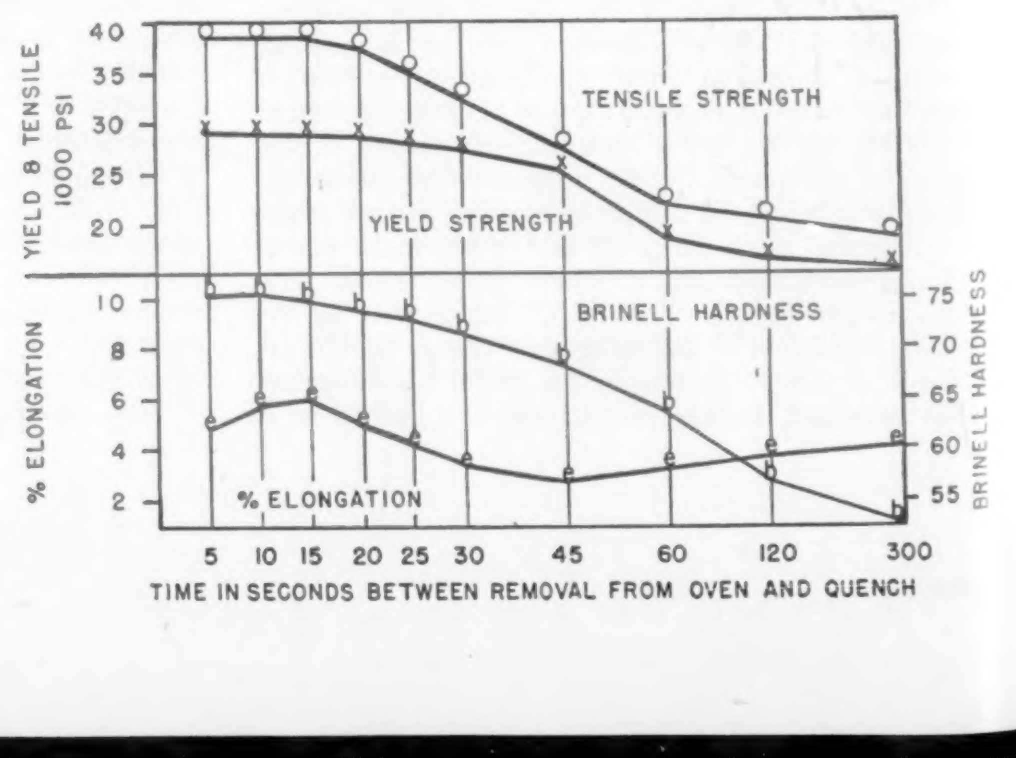
A Case History of Slow Quenching

In 1940 the author was fortunate to be able to test several hundred tensile bars which were duplicates of control specimens which had been broken at various times in the previous five years. The reason attention was directed to these duplicates, was a series of inexplicable failures of major units of war materiel. In many instances these units had favorably performed for as much as 4 years in peacetime applications and routine training programs. Fortunately the firm's records were accurate. The numbers on the castings actually were the numbers of representative control specimens. As all failures were shock or concussion failures and none were traceable to fatigue through overloading, design defects were ruled out.

The original test figures for the control specimens were examined. Without exception it was noticed that though they had been acceptable, they had barely passed. On an average the tensile figures showed 32,500 psi. with an elongation of exactly 3%. The retests were run on the duplicate bars. All failed to meet specifications. Bars which had aged at room temperature for as little as 2 yr. were failing both with respect to tensile strength as well as elongation. Bars which were 5 yr. old were completely embrittled, and frequently the fractures showed large clusters of copper colored segregation areas, unidentifiable by any available reference chart. The tests of the 195T6 alloy were expanded to include about 600 bars of all ranges of original strength. It was determined that all bars which had originally yielded results under 36,000 psi. with 4.5% elongation minimum had been unfavorably affected by the aging time. Elongation was effected most noticeably. Brinell hardness was exceedingly irregular. On the bars which failed with zero elongation the range of hardness as determined on Rockwell using the "E" and "H" scales varied from soft spots of 45 BHN to hard spots of 110 BHN.

On 195T6 bars which had shown figures in excess of 36,000 psi. plus 5% elongation on the original

Fig. 3—The time between removing the charge from the furnace and getting it into a quench effects several properties in varying degrees. Test pieces used for compiling these data were 0.505-in. standard pattern test bars of 195T6 aluminum.



tests, the aging at room temperature had very little effect. Fig. 4 is a set of curves determined from the average figures for bars in excess of 36,000 psi. and those which represented the failed production parts. All castings and bars were sandcast. All bars were broken with the as-cast surface untouched. In Fig. 4 the poor metal is represented as "slow-quenched" metal, the better as "rapid quenched." In the original series of tests it was not determined that the rate of quenching was the source of the fault.

An important supplementary series of tests was run on duplicate bars of 356T6 aluminum which had been cast in the same foundry and heat treated in the same ovens; quenched by the same crew with the same equipment. When it was noticed that not only did the average tensile and elongation figures for 356T6 exceed the specification minimums for 195T6, which called for 32,000 psi. with 3% minimum elongation, but that these original properties were not affected by the period of room temperature aging, the immediate research for that company was halted and the substitution of 356T6 for the other alloy was authorized for all future production.

Subsequent to the above incident, a series of tests were made to determine the exact reason for the embrittlement of the 195T6 alloy aluminum. The data on which Fig. 2 and 3 are based were obtained in these and other tests. Quench time tests were made on 24ST and 17ST copper aluminum alloys as well as on 356T6, 51S and 53S aluminum sheet alloys with silicon and magnesium and manganese. In all materials the curves were substantially the same as those shown in Fig. 3, except that for sheet materials of thin gage the rapidity of decline of the curves is much more pronounced.

Examination was made of the techniques of quenching in the foundry which had produced the castings which failed. A most uncommon quenching arrangement was in operation due to the fact that the foundry was located on the second floor of an office building and no provision was possible for installing the large tank of quench water so that it would be flush with the floor. It was therefore necessary to remove the charge of castings from the oven, hook a special hoist attachment to the hot carriage, raise the charge to the ceiling and transport it from 20 to 50 ft. to the tank. It required five men to guide the charge into place and position it over the tank. The operation was hot and dangerous.

There were two separate ovens, one close to the tank and in line with it, the other across the room and on a diagonal with the tank. This caused a basic differential to exist between the two ovens which invariably caused the remote oven to produce work of lower physical properties. This fact was common knowledge, so the foundry foreman, not understanding the reason for the difference, usually tried to place his less important work in the poorer quality oven. He blamed the oven, not the quench cycle.

Time tests showed the average minimum time of quench in the closest oven to the quench was 35 sec., for the remote one it was 70 sec. Frequently, however, the time would exceed 1 min. for the first and 2 min. for the second, depending upon several variables. All in all, the method of quenching was definitely the source of the basic difference between the good castings and those which became brittle. The firm had an excellent chemical control-laboratory routine which actually made and enforced composition control tests. The ovens were kept in good operating condition by monthly examinations and tests. But the best intentions, with the best basic metallurgical controls could not overcome the losses incurred during the quench cycle.

Several supplementary tests were subsequently run to cross check the effects of melting practice with heat treating response. These have been in part reported elsewhere. In all tests close attention has been paid to the loading of the furnace as well as the time of quenching. Further, in numerous instances it has been found that where partial rejection of lots of aircraft quality aluminum castings and forgings subject to 100% X-ray and hardness tests occurred because of low hardness, careful examination of the prior metallurgical history has disclosed either improper loading conditions prevailed or slow quenching was practiced. Correction of these two factors has invariably ended the production of lots of castings of varying hardnesses.

A final series of tests were run, however, some

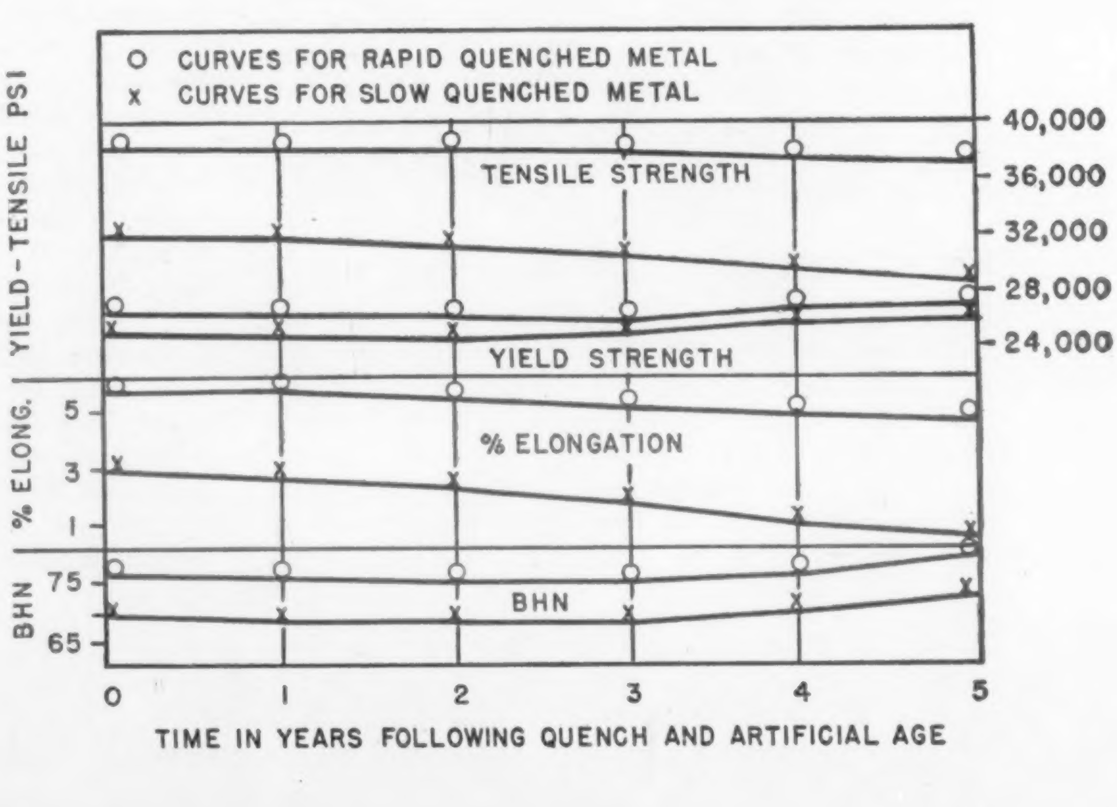


Fig. 4—Slow quenched 195T6 aluminum sand cast pieces showed a definite lack of stability as compared to the same material rapidly quenched.

Fig. 5—This is considered a highly satisfactory arrangement for rapid quenching of aluminum parts. The tank elevator top prevents steam from entering the furnace and provides a platform for reloading the furnace.

years subsequent to the original investigations, in which bars of several alloys were deliberately quenched in varying times, as illustrated in Fig. 3. The bars were quenched in duplicate. One bar would be broken after precipitation treatment, the other bar would be given a complete new solution treatment, quickly quenched, and aged for the normal time for precipitation hardening. Typically, for 195T6 the bars followed the curves depicted in Fig. 3 for those which were quenched at the varying times. All bars which were re-solution treated, quenched in 10 sec. and aged at 320 F for 4 hr. gave figures which averaged as follows: tensile strength, 39,700 psi., yield strength, 27,800 psi.; elongation, 7%; Brinell, 78 to 82; uniformity of structure was good and the fracture of all was fine grained without apparent effect from the prior heat treatment and slow quench cycle. All results obtained in all tests indicates the absolute essentiality of rapid quenching with proper loading practices.

How to Correct Processing Errors

Several conclusions can be drawn. Most important, with respect to alloy 195T6 is that new specifications should be written for the sand castings, at least, which raise the minimum requirements to 36,000 psi. tensile strength with a minimum elongation of 4%. Below these figures, the metal is either badly gased, of poor composition, or has not been heat treated properly and will prove to be unsafe in use. The silicon aluminum magnesium casting alloys, such as 356T6 aluminum, do not seem to be as susceptible to variations in quenching or heat treating loading techniques, but have the peculiarity of the need for close control of their magnesium content. The wrought alloys such as represented by 24ST or 17ST are very noticeably effected by the rate of quench, not only with respect to immediate tensile figures, but also with regards to their aging characteristics. This is usually stated as their resistance to corrosion, for slow quenching permits of the uncontrolled agglomeration of the hardening constituents in the grain boundaries in such a manner that electrolytic potentials are present which quickly cause galvanic corrosion when in contact with moisture. However, it is probably true that apart from the galvanic corrosion, slow quenched alloys containing copper would become embrittled by the loss of ductility and tensile strength in prolonged aging at room temperature in the absence of moisture. This is due to the continued agglomeration of hardening constituents along the grain boundaries, at the points initiated by the uncontrolled precipitation incurred by the delay in the quench cycle, or the failure of the hardeners to go into complete solution, coupled with inability of the material to be quenched in improperly loaded charges of forgings, spinnings, etc.

Fig. 5 shows a good layout for the heat treating and quenching of aluminum alloys. Observe that the tank is immediately available to the oven, but that the steam which is generated in quenching is excluded from the oven by a combination of a solid sheet steel top on the quench elevator with an exhaust stack and fan on the tank. Furthermore, the elevator cover is provided with tracks which permit immediate recharging of the oven without loss of too much heat. An improvement for larger load capacities is to provide a gravity operated winch for the elevator to eliminate the possibility of power or mechanical failure during the quench operation. The largest charge of castings can be safely dropped into a deep quench tank at gravity acceleration if adequate overflow provision and splash guards are provided, without damage to the castings. Too frequently quench cycles are operated on mechanically timed cycles which are so slow as to obliterate all gain from the mechanization. This is particularly true of bottom discharge ovens which are positioned above the tank. In such arrangements usually the descent of the charge is timed to allow for complete closing of the oven door to exclude the cloud of steam which rises from the quench. Many such installations have had cycles of quenching of considerably more than 30 seconds, with the result that all metal quenched from such ovens is uniform, but uniformly poor.

The best metal is frequently ruined for use by carelessness in the rather minor stages of loading and quenching. Careful attention to these details will always pay dividends in immediate economy with respect to straightening, re-heat treating or costly rejections. First make sure your equipment is right for the job, then use it sensibly. Somebody's life usually depends upon it.

MATERIALS & METHODS MANUAL 30

This is another in a series of Manuals on engineering materials and processing methods, published at periodic intervals as special sections in Materials & Methods. Each of them is intended to be a compressed handbook on its particular subject and to be packed with useful reference data on the characteristics of certain materials or metal forms or with essential principles, best procedures and operating data for performing specific metalworking processes.

Clad Steels

by The Editors, MATERIALS & METHODS

More and more industries now recognize the possible savings in materials costs attainable through the use of ordinary carbon steels which are faced with stainless, nickel and other heat or corrosion resistant materials. Likewise, engineers have learned that in most cases the clad steels are easier to fabricate than solid sections of those materials now used as cladding.

This manual presents the basic facts about clad steels, the materials involved, fabricating and finishing information and a comprehensive list of fields and applications where clad steels are serving.

Contents

Materials & Methods, September 1947

(Published since 1929 as Metals and Alloys)

Introduction

There are many types of composite metals and specially surfaced steels, but of this wide assortment there is only one group which fits the specification for clad steel.

By definition, a clad steel plate is a composite plate made up of a commercial grade steel plate, to one or both sides of which there is uniformly and permanently joined a veneer or cladding of a corrosion-or heat-resisting metal, the thickness of which is a substantial proportion of the total plate thickness.

A.S.T.M. specifications and the A.S.M.E. boiler code require a minimum bond shear strength of 20,000 psi. for clad steels. Most of the clads now offered for general use far exceed this requirement, some by more than two times.

Generally, the steels used for backing are plain low carbon types while the cladding consists of various grades of stainless steel, nickel, Monel, silver, copper, Inconel and cupro-nickel.

The primary reason-for-being of clad steels is to provide materials which are either corrosion-or heat-resistant, or both, on at least one surface and to make them available at less cost than solid sheets or plates of the expensive resistant materials.

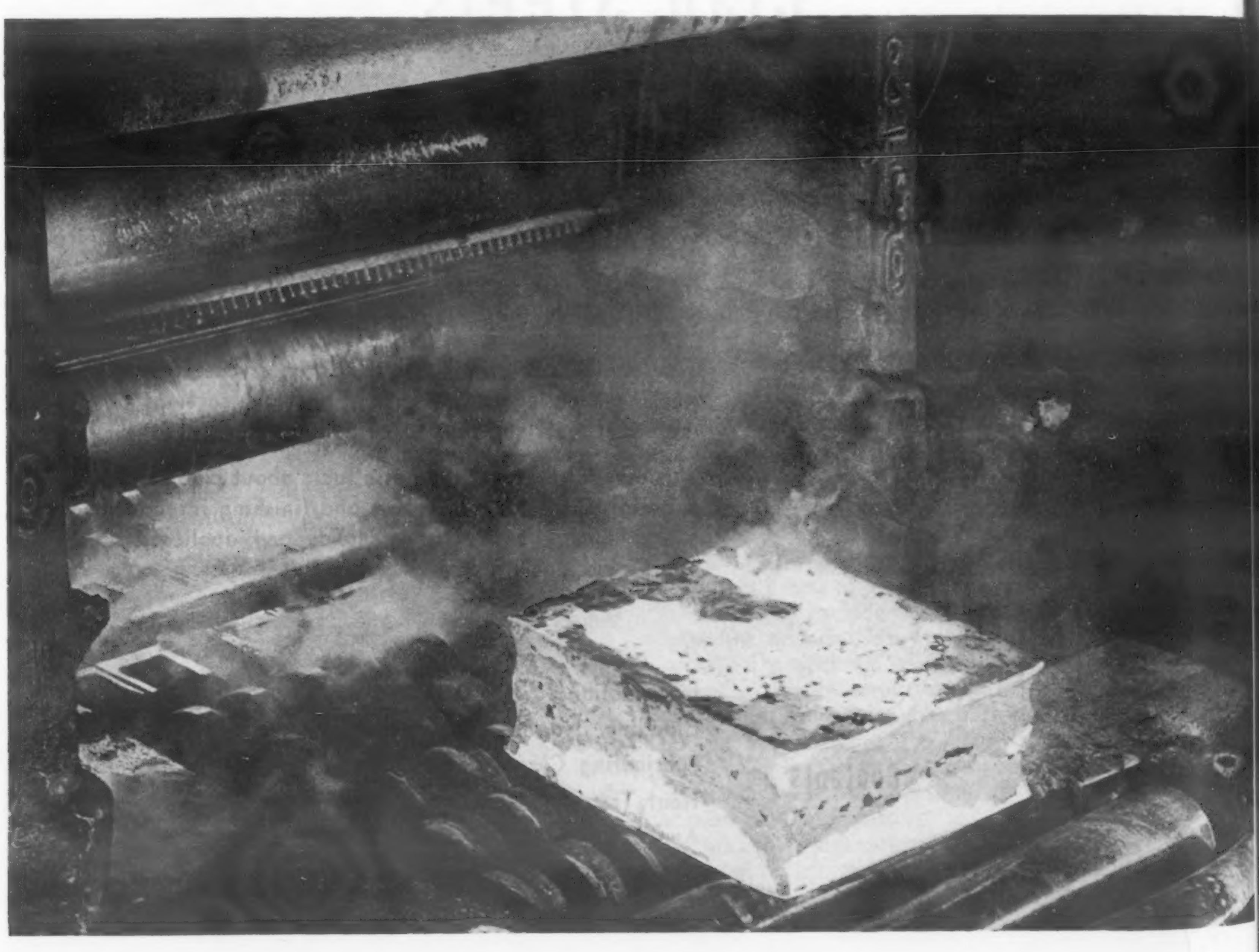
There are many ways of producing clad steels, each of which has its advocates. The results in service of the true clad steels vary little so long as the bond between the backing and the cladding results in an integral material and so long as the thickness of cladding is uniform in thickness.

Here, in essence, are the principal methods of forming clads:

Heat and pressure method. In this method a heavy slab of steel is blasted and cleaned on one of its flat surfaces and then a similarly prepared plate cladding material is placed on th steel slab and held in place by wel and bars. A second similarly prepar slab and plate of cladding is put a the first with the clad surfaces facin but kept apart with an infusible pa ing compound. This composite san wich is heated thoroughly up to abo 2300 F and then rolled down to desired thickness. The combination heat and rolling pressure bonds th cladding and steel. As a final step, th composite parts are separated at th parting compound, resulting in tw clad steel plates.

Casting Method. One type of cl is made by casting mild steel aroun

All true clad steels are furnished in th wrought condition. Here a large plate has started to reduce a "sandwich" to for a standard clad plate.



an assembly of two stainless steel plates edge welded and separated by insulating material. The composite which results is then rolled down to size. Separating the composite between the two stainless surfaces yields two plates of clad steel.

Intermelting. Billets of carefully cleaned and prepared forging quality steel are heated to controlled temperatures and are centered within refractory molds in such a manner that open space exists between billets and refractory walls. Into this space molten copper is poured. The copper welds to the steel. The product is completed by rolling, drawing and annealing operations.

Arc Welding. Beads of cladding metal are deposited upon the backing metal from welding rods, one bead being deposited upon another until the desired thickness is secured, after which the necessary rolling and wroughting is performed.

Fusion Welding. A thick slab of backing metal is laid flat. Removable plates are so applied to the sides of this slab that they project beyond its upper edge, their projections thus forming the sides of an open ended box of which the slab is the bottom. This box is filled with powdered or otherwise small sized metallic materials and slag which, when fused, will alloy into the desired cladding metal. Heat for fusion is applied by gas or by electricity, the fusion temperature being sufficient to weld the cladding to the backing metal. The side plates are removed. The composite is then rolled to size.

Resistance Welding. One or more sheets of cladding metal placed upon the backing metal may be resistance welded by overlapping spot, seam or other means, after which the weld may be improved by hot rolling.

Why Clad Steels?

While most clad steels are less expensive than a solid sheet or plate of the corrosion- or heat-resistant material used, this is not always the case. However, there are some circumstances which justify the use of clads even when they are more expensive than the solid cladding material.

Welding of clad steels is generally easier than would be the welding of the cladding material alone. This is true of Monel clads particularly, and often results in selection of a clad rather than using solid Monel.

One method of making clad steel is to join an accurate thickness of alloy to the mild steel backing and then roll the "sandwich" down to size. (Courtesy Lukens Steel Co.)

In other cases the clad material can be more severely drawn in one step than would be possible with, for instance, solid stainless which often requires several intermediate anneals. This characteristic is taken advantage of by one producer of cooking utensils, which uses double stainless clad.

In many applications high heat conductivity is essential. Since solid stainless does not conduct heat too well, clad stainless is resorted to, with excellent results. Copper clads are often used for this reason. Carbon steel to which the cladding materials are joined is a better conductor of heat than is stainless steel or nickel. Copper and silver as claddings are better conductors than the backing steels.

Occasionally both materials joined in a clad steel have characteristics that are suited for the product under consideration. An example is a washing machine where the inside surface is of stainless steel while the outside, or backing surface, is of carbon steel which can be porcelain enameled to match the legs and other parts of the unit.

While not so important now as during the past war, clad steels make possible the stretching of supplies of scarce alloys.

General Factors

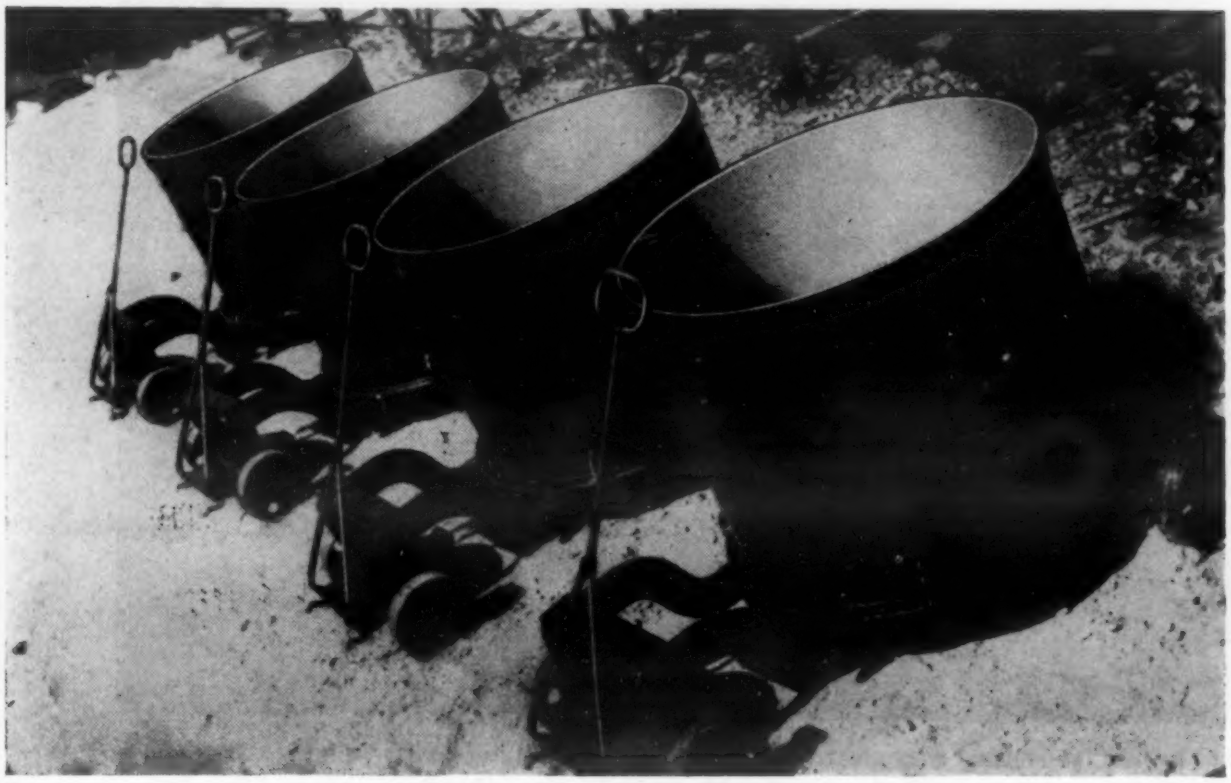
Clad steels, as has been pointed out, are made with the cladding on either one or both surfaces of the backing steel. Cladding is usually specified in percentage of total thickness of the complete sheet or plate regardless of whether one or both surfaces are clad. Thus, a 20% stainless clad plate with a total thickness of 1 in. would consist of 0.8 in. carbon steel and 0.2 in. stainless.

The most common thicknesses of cladding are 10 and 20%, but the thickness may vary from 5 to 50%. Some industries, notably the petroleum refiners, specify cladding thickness in fractions or percentages of an inch. Of course, the thickness of cladding is determined by the requirements of the intended application, but because of fabricating problems the minimum of cladding is generally held to 0.050 in., with an absolute minimum of 0.030 in.

Handling of Clads

With single clads, the material should be handled in such a manner that the cladding material is always protected. Some fabricators cover the clad side with paper or a strippable plastic coating. Most fabricators handle the plate around their shops with the clad side up to prevent the more costly, special-purpose surface from scratches or from being gouged. Tools and surfaces which come in contact with the cladding should be wiped clean of loose scale, steel particles or other foreign materials that could become embedded in the cladding.

Scratches, gouges and embedded materials reduce the cladding thickness at those points and often act as focal points for corrosion.



Nickel clad steel is used in these varnish kettles which serve under rather severe conditions. In this illustration the nickel-clad interiors are easily seen.

Cladding and Backing Materials

At the present time the greatest demand for clad steel is for those types clad with various types of stainless steels, although large tonnages are sold of clads utilizing the high nickel alloys, silver, copper and cupro-nickel.

Following are the materials used most generally as cladding. The types of stainless steels most commonly used are 405, 410, 430, 304, 316 and 347.

Stainless Steel (Chromium)

Type 405 a straight chromium, with slight additions of aluminum, is nonhardening, magnetic steel which attains its nonhardening characteristic after air cooling from high temperatures. Type 405 is used extensively at elevated temperatures to resist oxidation and corrosion.

Type 410 (12% chromium) is the basis material from which Type 405 is derived. This steel is hardenable and finds many corrosion and oxidation resisting applications where high temperatures are involved.

Type 430 (14 to 18% chromium) is somewhat similar in characteristics and uses to Type 405. The heat affected zones of welded areas are brittle and must be annealed to attain ductility. It has excellent corrosion and oxidation resistance.

Stainless of the 14 to 16% chromium type lies between Types 410 and 430 in its characteristics. It does not harden as much as the lower chromium types and at the same time is more ductile than those with a higher chromium content. It is relatively easy to weld and has high corrosion and oxidation resistance.

Chromium-Nickel Steels

Steels in this group contain chromium in the range of 16.0 to 26.0% and nickel from 6.0 to 22.0%. Other alloying elements may include titanium, molybdenum and columbium. Heat treating does not have the effect of hardening these steels which are nonmagnetic, but severe cold-working causes them to harden and become magnetic. Generally, the following steels are referred to as austenitic stainless steels.

Type 301 (18:8) is used where corrosive conditions are relatively mild, including applications where sanitation and decoration are important considerations.

Type 302 (18:8) slightly higher in both chromium and nickel content is well suited to many chemical applications as well as for sanitary and decorative uses.

Type 304—an 18:8 stainless steel is low in carbon content and thus less susceptible to carbide precipitation during welding than are Types 301 and 302. It can be built into equipment subjected to a wider range of corrosive conditions and does not require subsequent heat treating.

Types 309 and 310 (20:12) stainless have the highest chromium and nickel contents of the austenitic stainless steels and both are high in resistance to oxidation and corrosion.

Type 316 stainless is of the 18:8 grade with slightly higher nickel (10%) plus 2 to 3% molybdenum. Corrosion resistance is slightly higher than regular 18:8 types and the molybdenum reduces the tendency towards pitting or pin hole corrosion.

Another modified 18:8 stainless used is Type 321 which contains titanium to prevent precipitation of carbides. This steel is chosen for welded vessels to be used under some corrosive conditions, when the service temperature range is 800 to 1600 F, or if the vessel is to be stress relieved. Columbium electrodes (Type 347) are used for welding the clad portion of Type 321 clad steels.

Columbium is used in Type 347, another modification of 18:8 stainless used as a cladding material. The columbium prevents carbide precipitation. Clads of 347 or 321 are used under much the same conditions.

Nickel and High Nickel Alloys

Nickel, with its superior resistance to hot concentrated caustic soda, is used as the cladding material for many types of equipment used in alkali, rayon, soap and other process indus-

tries. Heat conductivity of nickel is high so it is good for both heating and cooling. Nickel should not be used where it will be in contact with nitric and other oxidizing acids or salts, but can be used under both high and low temperature conditions.

"L" Nickel, which contains 0.02% (max.) of carbon, is often used as a cladding for high temperature applications. Among the corrosive media for which "L" Nickel is recommended are fused salts above 850 F as well as fused caustic and fused nitrates.

Inconel (80 nickel, 13 chromium, 6.5% iron) adds to the characteristics of nickel the corrosion and heat resistance of chromium. Its characteristics are such that it can be heated to 1600 F and then cooled to 0 F repeatedly without embrittlement. Inconel is superior to other cladding materials in its resistance to alkaline sulfur compounds and hydrogen sulfide at both atmospheric and high temperatures. The chromium helps it resist strongly oxidizing acid solutions and dilute organic acids. This cladding material is not affected by dry gases at atmospheric temperatures or mixtures of steam, air and carbon-monoxide nor by steam at 800 F. Media for which Inconel is recommended include magnesium chloride, fruit juices, dairy products, wines, fatty acids, pharmaceuticals, edible oils and dyestuffs.

Monel is the final nickel alloy used as a cladding material. The combination of high strength, toughness and immunity to rust makes its application widespread. Additional characteristics in its favor are ease of fabrication, and corrosion and abrasion resistance. It is widely used in connection with the handling of common salt, dilute sulfuric acid, cold dilute hydrochloric, hydrofluoric and phosphoric acids and strong caustic soda. Monel is not resistant to ferric chloride, nitric acid and sulfurous acid. A wide range of strength is obtained in Monel through mechanical working.

Other Cladding Materials

Silver, copper and cupro-nickel are the other materials most frequently used for cladding. Silver and copper are often used where heat distribution and conductivity are a problem of the application.

In the case of silver, even though the cost of producing clad plate is high due to the number of times it must be heated during the rolling operation, it is still cheaper to use a clad than it is to use a solid piece of silver.

Copper-clad steel is used rather extensively for transmission of electricity, the copper because of its electrical conductivity and the steel for strength. Now, copper clads are finding other applications in the form of sheet and plate.

Base Metals

Carbon steels or other mild steels (including low alloy steels) are used as the base metals for clad steels. Most steels used meet the ASTM specifications for steel of flange quality or better. For special applications other types of steels can be used for backing.

Steels most commonly used are known as being of flange or firebox qualities and are identified by ASTM specifications A285, grade C; A201, grade B; A212, grade B; A203, grade B; A204, grade B, and, A225, grade B.

These steels range in tensile strength from a low of 55,000 to 65,000 psi. to a high of 70,000 to 80,000 psi. Yield strengths average slightly over ½ the tensile strength. The lowest of the group as far as physicals is concerned is A285.

Available Forms

Practically all of the clad steels are available in the form of plate, sheet and strip and some, particularly copperclads are available as wire. Some producers of clads also do some prefabrication to produce such shapes as heads, flanges, circles and cut shapes.

Generally, the widest sheet or plate that can be used should be specified, since a plate 178 inches wide is much more economical than two plates of half that width to achieve the same necessary fabricated width. The reason for the economy of the wider sheet in connection with clad steels is due to the fact that the wide plate requires considerable less finishing, grinding and other preparation than would be required for two plates of lesser width.

Plate Sizes of Clad Steels

Thickness In.	WIDTHS, IN.																						DIA. OF CIRCLE
LENGTHS, IN.	48	60	66	72	78	84	90	96	102	108	114	120	126	132	138	144	150	156	162	168	174	178	
3/16	480	480	480	480	480	480	440	410	385	365	345	330	315	300				For sizes beyond these limits refer to producer.					132
1/4	480	480	480	480	480	480	440	410	385	365	345	330	315	300	260	220	180						150
5/16	480	480	480	480	480	480	480	480	480	480	470	450	430	410	390	370	360						150
3/8	480	480	480	480	480	480	480	480	480	480	470	460	440	420	400	380	370	325	310				162
7/16	480	480	480	480	480	480	480	480	480	480	480	480	460	430	410	390	370	325	310				162
1/2	480	480	480	480	480	480	480	480	480	480	480	480	460	440	430	410	370	325	310	195			168
9/16	480	480	480	480	480	480	480	480	480	480	480	480	480	460	450	430	380	325	310	195			168
5/8	480	480	480	480	480	480	480	480	480	480	480	480	480	470	460	440	390	340	310	195	180		174
11/16	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	460	400	350	310	195	180	178	178
3/4	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	460	410	360	310	195	180	178	178
7/8	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	460	420	370	310	195	180	178	178
1	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	460	430	380	310	195	180	178	178
1-1/4	480	480	480	480	480	480	480	480	480	480	480	480	460	435	420	400	385	370	310	195	180	178	178
1-1/2	480	480	480	480	480	480	480	480	480	450	425	405	385	365	350	335	320	310	300	195	180	178	178
1-3/4	480	480	480	480	480	480	465	435	410	385	365	345	330	315	300	285	275	265	255	195	180	178	178
2	480	480	480	480	470	435	405	380	360	340	320	305	290	275	265	255	240	235	225	195	180		174

Fabrication of Clad Steels

Many of the preliminary steps to the making of products of clad steel plate are done in plants of the producers of the material. Such work is, in effect, prefabrication, since operations include shearing and punching, bending and rolling, machining, and flame cutting. However, prefabricating can also be done in plants of the consumers.

Shearing and Punching — Shearing and punching are done with the clad side of the material up so the burr is formed on the steel side. Where welding is to follow care should be taken to prevent excessive shear droop, which results from shear pressure, and breaks the flatness of the plate's clad surface. If the plate edge is to be machined the shear droop effect can be disregarded. Likewise, the effect on light gage sheet is of no serious consequence.

Bending and Rolling—Clad steels should be in the annealed condition prior to their being formed on press brakes or rolled in bending rolls. Since spring-back occurs in bending, radii should be as large as possible and include compensation for the spring back. Bending and rolling should be performed hot when low-alloy steel backing is used for heavy gage clad plate. The straight chromium-clad materials are not as ductile as most other clad materials so allowances must be made for this factor both in design and in fabrication. Before bending and rolling, all working surfaces of both plate and equipment should be thoroughly cleaned to remove all loose scale and chips which could become embedded in the clad plate and serve as focal points for corrosion. For many applications, clad plate which has been rolled or bent should be given a subsequent stress-relieving anneal. This is particularly important where severe cold working sets up stresses that cause the material to be more susceptible to certain corrosive media.

Machining—Feeds and speeds identical with those for mild steels are suitable for machining the base metal of clad steels. With all types of cladding, speeds should be somewhat lower than for steel, but feeds should be firm. When chromium-nickel claddings are involved care should be taken to see that the tool does not ride the clad surface, since this will cause the material to work harden and gall.

Flame Cutting—Since most of the alloys used to clad steel are resistant to heat and oxidation, flame cutting is accomplished by the successive oxidation of the white hot metal and removal of the oxide in the form of slag. The cladding is removed by melting of the alloy and the erosion effect of the stream of oxygen and slag.

Little difficulty is experienced in flame cutting the straight chromium and austenitic stainless clad steels, but Monel and Inconel clads cut less readily. With the latter materials it is found advantageous to preheat to a dull red before starting the cut.

Cuts are made with the backing steel on top and after all scale has been removed, using cutting tips one or two sizes larger than would ordinarily be used for the same thickness of steel. The cutting torch is generally inclined from 5 to 20 deg. toward the direction of cut to aid in the production of slag and start a washing action.

Preheating is generally recommended except when 10% cladding is involved on material ¼-in. thick and less. Preheating is done, with a regular torch, to a dull red.

Welding

Welding is the universally accepted method for joining clad steels. *Arc welding* is most generally used, except in the case of thickness 18 gage and less. *Gas welding* is seldom used on heavy-gage clad steel and *resistance welding* is said to have practically no place in fabricating clad plates. *Atomic hydrogen welding* is considered the most satisfactory method of joining silver clad and light gage clad steels.

Metallic Arc Welding

Butt Welds (Light Gages)—When butt welding the lighter gages of clad sheets it is not necessary to resort to any special edge preparation. There should be a slight spacing between the edges being joined. In the range of 18 to 16 gage electrodes must be carefully selected and the welding done from the clad side in one pass. In gages from 14 to 11 two passes can be used to complete the weld—the first from the clad side and the second from the backing side. In the latter case steel electrodes can be used on the backing side.

Butt Welds (Intermediate Gages)—In thicknesses from 10 gage to 3/16-in. plate the edges of the steel side are beveled preparatory to welding. The bevel does not reach the cladding metal. The steel side is welded first with a covered steel electrode. After completing the weld on the steel side, all slag is removed from the clad side of the groove and then the weld completed with one pass of a 3/32-in. electrode of a material comparable to the cladding.

Butt Welding (Heavy Gages)—Welds in clad steels 3/16-in. and over are usually required to have the minimum in strength, ductility and corrosion resistance, thus extreme care must be used in joining sections of these materials. Recommended procedure follows:

Edges are machined or otherwise beveled from the backing side and maintaining a lip about 1/16-in. thick above the cladding. The lip should be of uniform thickness since it serves as a barrier to prevent contamination of the mild steel weld metal by the high alloy cladding material.

Next the edges to be joined are carefully aligned and the assembly tack welded on the backing side. Accurate alignment is essential to a good joint.

The welding is then carried on on the steel side through use of a rod which will develop the same properties as the backing material. The root head is fused to the base of the steel lip but should not penetrate into the cladding. Penetration into the cladding is likely to form an extremely hard brittle weld metal which lacks the necessary ductility.

After the backing side has been welded, the clad side of the joint is cleaned by chipping or grinding down to the point where clean, sound weld metal is reached. Cleanliness of joint is important for two reasons. First, unfused areas might act as stress raisers, and, second, slag remaining from the steel weld might regasify, when alloy beads are applied, and cause porosity.

Next the clad side is welded using the rods recommended for the types of cladding being handled. The choice of alloy rod depends somewhat upon the most important properties desired

in the clad side of the joint. Varying percentages of alloying elements are last in the welding process, thus such losses must be anticipated. For instance, if titanium were used in normal amounts in the electrode the weld metal would show no titanium. An electrode having 19% chromium results in weld metal with 17 to 18% chromium. There is little or no loss with nickel and molybdenum, while about 25% of columbium is lost.

Fillet Welds—Fillet welds on clad steel plate generally are made with welds on the steel side first using an electrode which is suitable for joining dissimilar metals, since one surface is carbon steel and the other an alloy. The fillet weld joining two clad surfaces should be of the same general composition as the cladding material.

Seal and Lap Welds—In those cases where it is necessary to weld the steel backing of one sheet or plate to the clad surface of another piece as in the case of lap welds, or in sealing the edges of the clad sheets or plates, the welds in contact with the mild steel should be made with the same electrode used on the clad side.

Submerged Arc Welding

Submerged arc welding is used rather extensively by many fabricators of clad steel products. This welding method requires that considerable caution be exercised, since the high heat of the method can cause deep penetration and result in fusing of a large part of the base metal to mix it with the welding electrode. The heat problem must be given consideration in welding both the steel and alloy sides.

A fully killed steel should be chosen as the backing material for clads that are to be joined by submerged arc welding to result in satisfactory welds. One such satisfactory steel meets the specifications for ASTM A-201.

Care should be taken to prevent any penetration of the steel weld into the cladding. The plate edges are prepared as for ordinary metallic arc welding with the exception that the steel lip should be slightly thicker, extending from 1/16 to 3/32-in. above the cladding. One or two beads laid manually help to provide a backing for the submerged arc weld and prevent alloy pickup in the weld metal.

In welding the clad side, the groove should be cleaned out by chipping, grinding or machining until sound weld metal is reached. However, the groove should be kept to a minimum so that the alloy weld will not be diluted by backing metal. In many cases, the clad side is manually welded, due to the small thickness of cladding.

Considerations for Specific Materials

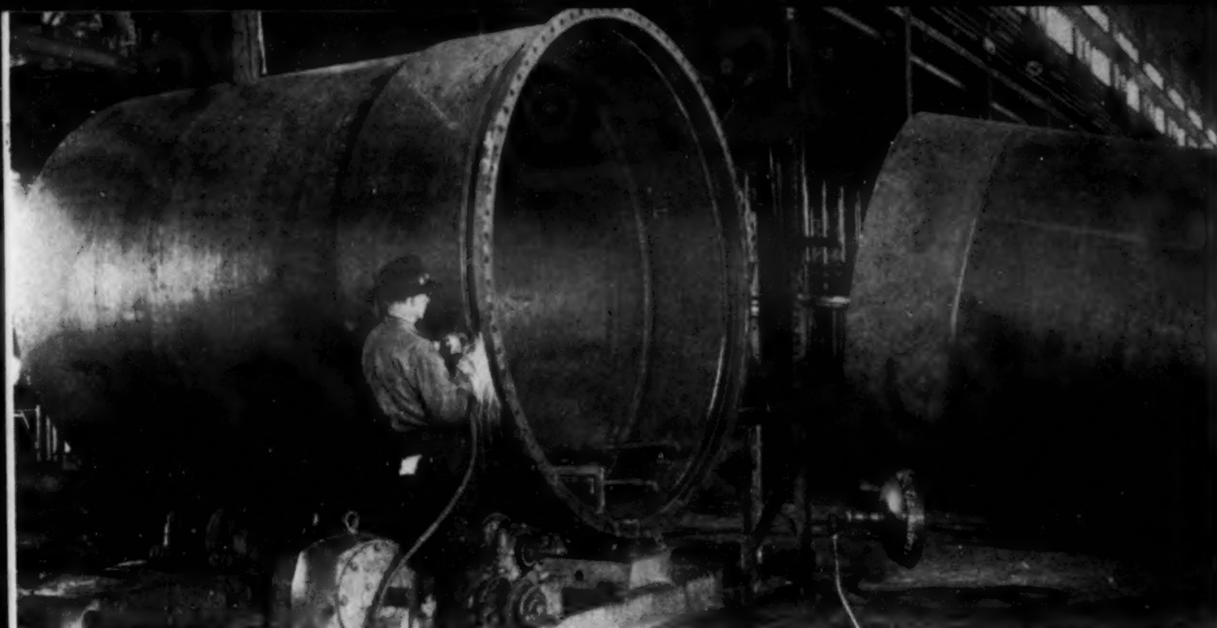
Straight Chromium Cladding—For some applications it is necessary to weld a straight chromium cladding with straight chromium electrodes. Dilution of the weld metal by pickup of the backing steel can be avoided by using an electrode of higher chromium content than that of the cladding or by using a number of successive layers with electrodes having the same analysis as the cladding.

Straight chromium clad materials are usually welded with austenitic electrodes to eliminate the brittle characteristics of straight chromium weld metals. Austenitic chromium-nickel electrodes of the 25-20 or 25-12 analysis are most frequently used. Although this type electrode does not result in brittleness in the weld metal, it does cause brittleness in heat affected zones of the backing plate.

A stabilized austenitic electrode should be used if the weldment is to operate in the carbide precipitation temperature range, or if stress relieving heat treatment is required.

Types 410 Modified and 430 Modified—These materials are somewhat brittle in the as-welded condition. Type 410 has air-hardening characteristics and Type 430 is inclined towards brittleness associated with grain growth. Both materials should be preheated to between 300 and 400 F and held at that temperature range during welding. The preheat can be done at the welt zone and the entire weldment given a

Since welding is the accepted method of joining clad steels it is important that the welding be done properly to retain the original properties of the cladding as well as those of the backing material. Welding always starts in the backing material, sufficiently removed from the cladding to prevent embrittlement in the weld area.



It is important that welded areas be thoroughly cleaned. Here a workman is grinding down a weld area before the final weld is made.

stress relieving treatment immediately following welding and prior to cooling.

Chromium-Nickel Cladding

To attain utmost corrosion resistance with chromium-nickel cladding materials it is important that the alloy weld metal not be contaminated through pick-up of steel backing. Dilution can be controlled by using an electrode of higher alloy content than the cladding or by depositing thin layers with electrodes of the same content. A common procedure is to run the root bead with 25/20 or 25/12 electrodes and then complete the weld with electrodes of the same composition as the cladding.

Types 301 and 302—Due to their high carbon content these materials are seldom used for highly corrosive conditions because of the danger of carbide precipitation. Since these clads are usually used in the lighter gages they are often welded with 25/20 or 25/12 electrodes throughout their component thickness.

Types 321 and 347 Modified—These cladding materials are welded with columbium bearing electrodes, since titanium is oxidized in the welding arc. The root pass is usually made with columbium stabilized 25/20 or 25/12 electrodes. However, to overcome crack sensitivity sometimes found with those electrodes, the root pass is sometimes made with unstabilized electrodes of the same general composition and then followed up with the stabilized electrode.

Type 316 Modified—The root pass weld of this material is usually made with 25/20 or 25/12 electrodes containing molybdenum and succeeding layers with 19/9 molybdenum electrodes.

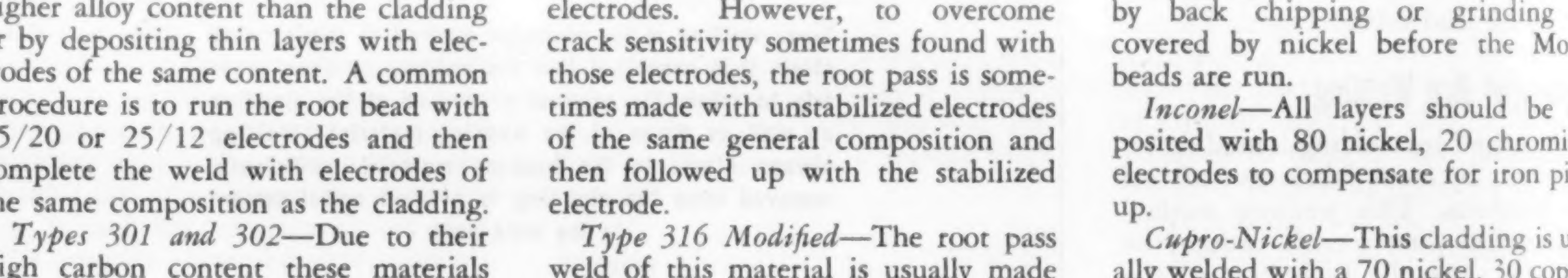
Nickel and Nickel-Base Claddings

It is impossible to use an electrode that will always compensate for iron pickup when welding pure nickel-clad steels. For most applications a severe limitation on iron content in the weld metal is not required since the resultant alloy is sufficiently corrosion resistant. Where iron pickup must be held to a minimum, the top half of the root bead should be chipped or ground off before the succeeding layers of weld metal are deposited. The greater the number of layers of weld metal, the lower will be the iron content in the top layer. Since there are many variables in welding nickel clads it is safest to consult producers of the material before settling on a procedure.

Monel—Due to a hot-short condition sometimes encountered when a Monel electrode is deposited against steel, the root pass and all but the cover passes should be made with a Monel electrode. It is important that the steel exposed by back chipping or grinding be covered by nickel before the Monel beads are run.

Inconel—All layers should be deposited with 80 nickel, 20 chromium electrodes to compensate for iron pickup.

Cupro-Nickel—This cladding is usually welded with a 70 nickel, 30 copper electrode, using multiple layers to overcome dilution.



The interior of this heat treating tank for handling sodium nitrate at 920 F is made of 20% nickel clad steel.

Heat Treating, Cleaning and Finishing

Preheating for Welding

Some of the cladding materials require preheating before welding to lower the temperature differential between base metal and weld metal. Preheating serves to prevent cracking in both base and weld metals and helps reduce shrinkage stresses and distortion. Simple designs and light gages do not often require preheating. A preheat of 300 to 400 F is recommended if the backing steel is high in tensile strength, the plates are thick or the weldments are rigid in design.

Preheating is necessary in welding all straight chromium stainless clad steels except type 405. Type 410, being martensitic and susceptible to small changes in carbon content, has pronounced air hardening tendencies unless the carbon content is less than 0.08%. The other straight-chromium clads (14 to 16% chromium and 16 to 18% chromium) are brittle in the as-welded condition and should be preheated.

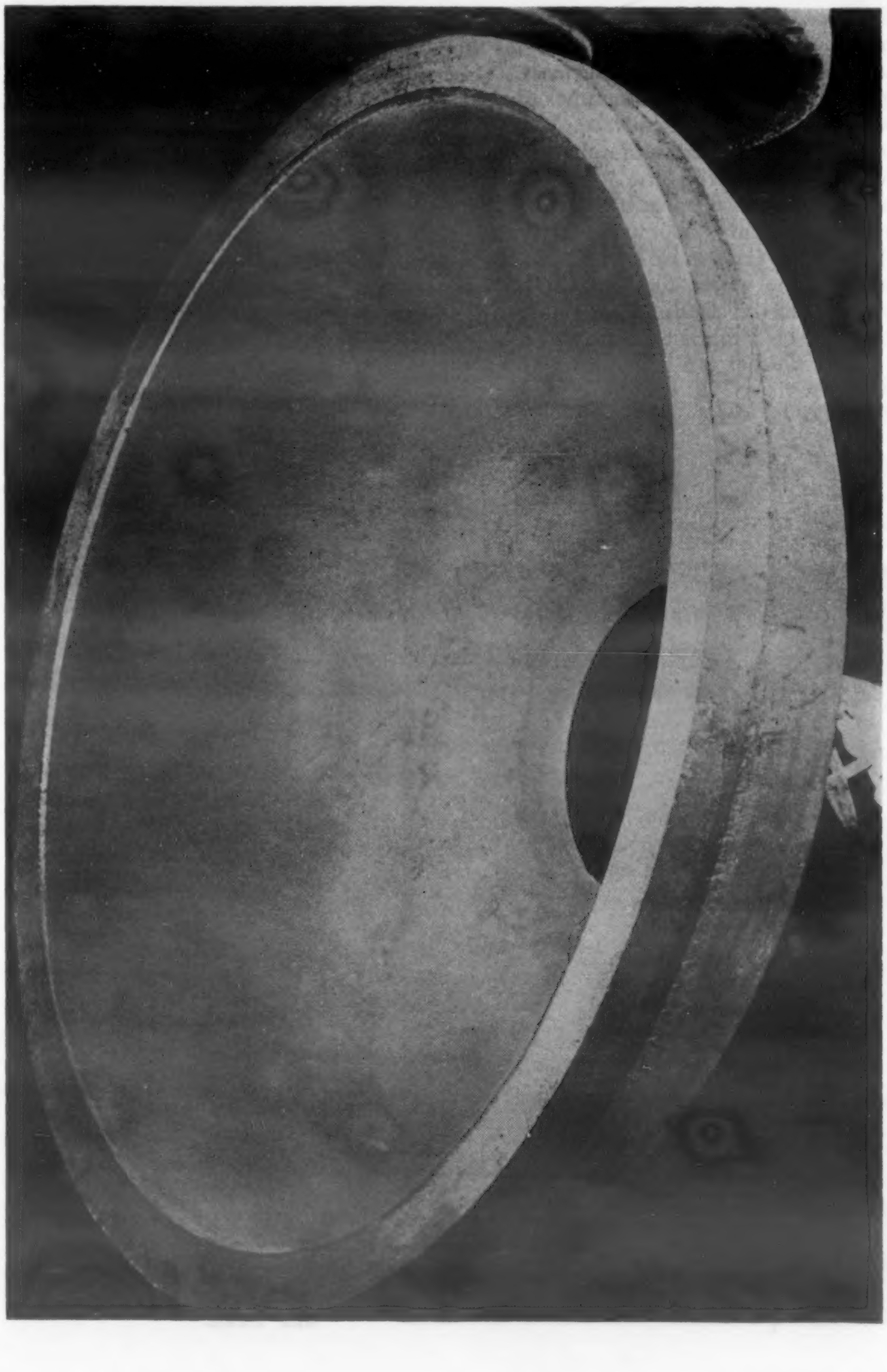
The previously mentioned preheating temperature of 300 to 400 F should be reached and then maintained during welding. After welding has been completed the structure should be annealed before cooling.

Nickel-, Monel- and Inconel-clad steels do not require heat treatment after fabrication except in the case of pressure vessels which might need a stress relief treatment. With these cladding materials stress relief is carried on at the same temperature required for the carbon steel backing, namely 1110 to 1250 F and holding for 1 hr. for each inch of material thickness and then cooling slowly in the furnace in still air.

A temperature of 1200 to 1250 F produces the greatest amount of carbide precipitation in austenitic stainless steel, so these materials cannot be subjected to normal stress relief temperatures unless carbon content is low or titanium or columbium is present as a stabilizer.

Types 321 and 347 are stabilized and can be heated to the usual stress relief temperatures without danger of carbide precipitation. For some corrosive conditions those two types of cladding are stress relieved at 1550 to 1650 F and held for 2 hr. per inch of thickness.

Type 410 stainless will harden at slow cooling rates so weldments of this material are heated to between 1450 and 1500 F held at that temperature, furnace cooled at the rate of 50 F per hour down to 1100 F and then



Clad steels are often furnished in forms other than sheets and plates. Here, for instance, is a large head for a pressure vessel as formed by Lukens Steel Co.

cooled in still air. The same treatment is suitable for Type 430 except that the heating temperature range is 1500 to 1550 F.

Type 405 is ferritic and not subject to hardening, but the areas adjacent to the weld might be brittle, thus the structure should be heated to 1400 to 1500 F after welding. Although this treatment is intended primarily to attain high ductility in the weld metal and heat-affected zone, it will also relieve internal stresses.

Finishing

Grinding—Often the service requirements of the product made of clad steel demand that weld surfaces be ground smooth and sometimes flush with the surrounding surface. Rubber or Bakelite bonded aluminum oxide wheels of 16 to 36 grit are generally used for the first grind, operating at speeds from 5,000 to 6,000 linear ft. per sec. Care must be exercised to see that the wheel does not tilt so as to bite into the cladding, since in many cases the cladding is extremely thin.

Finer finishes can be attained with a wheel with a grit size ranging from 40 to 60, or even finer.

Buffing and Polishing—Unbleached muslin wheels are used to buff and polish clad steels. The wheels should be sewed so as to provide stiffness near the center and flexibility at the edges. Aluminum oxide or silicon carbide can be used as the abrasive. When grit sizes are changed the wheel direction is altered 180 deg. to eliminate wheel marks.

Cleaning

Sandblasting—Sandblasting of clad steels requires no special techniques or precautions except to make certain that the sand is clean and iron-free. The blast should not be permitted to dwell for too long a period since this might cause local erosion and surface irregularities. Pickling and passivation often follow sandblasting to make certain that all scale and embedded iron is removed.

Pickling—Clad steels should not be pickled in the normal manner, since the strong acids and the time required to remove scale from stainless steel cladding will provoke excessive attack on the backing steels. It is recommended that acid solutions be applied by swabbing or by use of a paste so as to confine pickling action to the clad surface. It is important that pickling solutions be checked often since they are likely to pit as they become exhausted.

Surface condition and type of scale have more to do with pickling solution than does composition of the cladding. In pickling stainless, the acids attack the scale rather than the metal itself and thus the removal of oxides takes considerable time even in extremely active pickling solutions.

Pickling solutions as well as practices vary, but generally a solution of 15 to 20% sulfuric acid at 170 to 180 F is satisfactory for the first pickle. A finish solution of 15 to 20% nitric acid plus 1 to 2% hydrofluoric acid is quite satisfactory.

Careful rinsing should follow pickling.

Sodium Hydride Descaling—This new process results in pickling without loss of metal and is quite well suited to descaling stainless clad.

Passivation of Stainless-Clads—Passivation is the artificial formation of oxide films on stainless to add to its corrosion resistance. Nitric acid is highly efficient as an oxidizing agent. After the stainless surface has been cleaned of scale, grease, oil and other foreign matter it is immersed in a 20 to 40% solution of nitric acid for 15 to 30 min. at temperatures between 120 and 140 F. Filling the vessel with this solution or swabbing is accepted procedure. Scrubbing and rinsing with hot water should follow passivation.

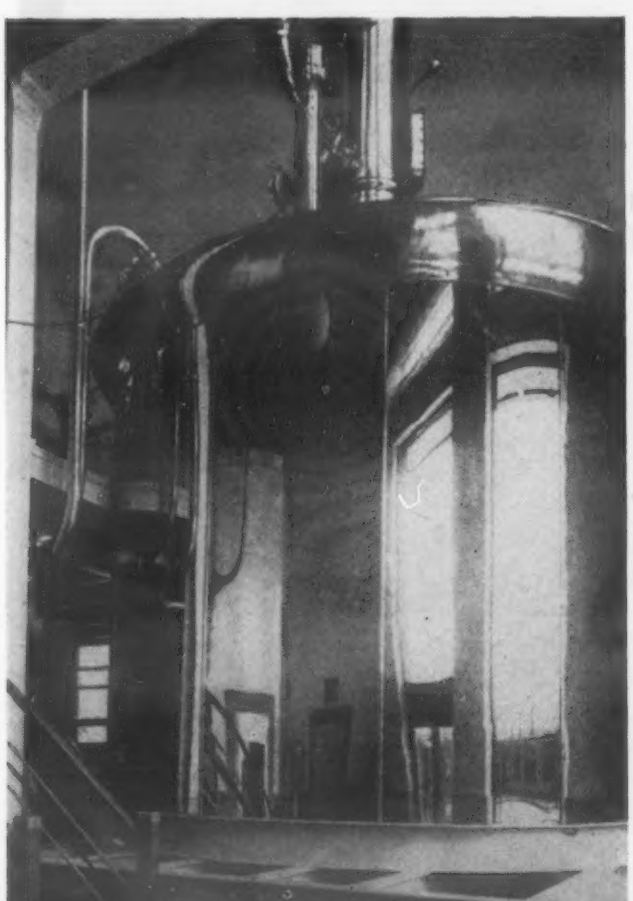
Passivation is not permanent and does not prevent corrosion but does act to slow down the corrosive rate.

Acid Washing—There is always danger of clad corrosion resistant materials picking up iron in the form of dust or small particles. Such particles can act as focal points for corrosion and often lead to contamination. To remove iron particles acid washing is recommended for completed products.

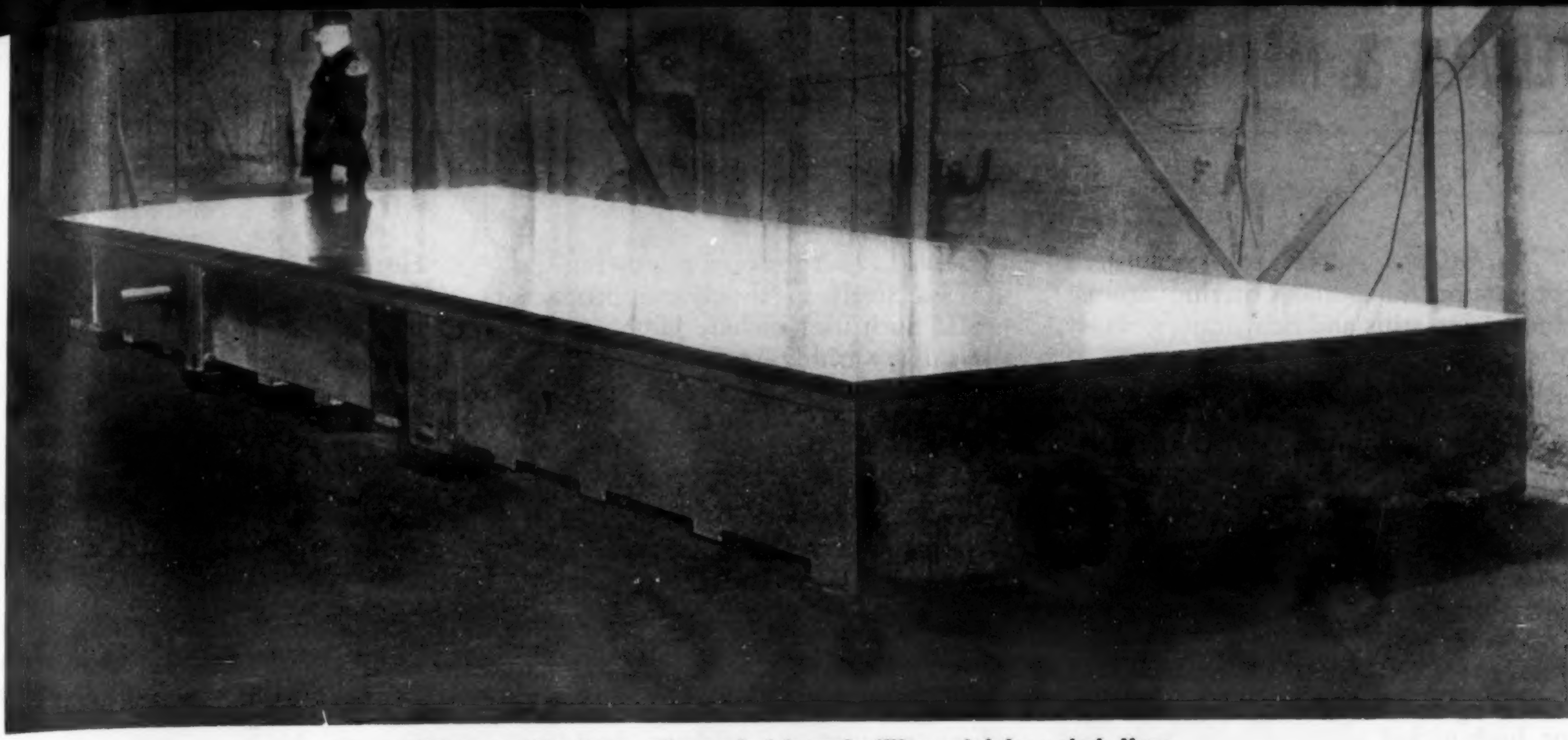
All dirt and grease should be removed through such cleaning agents as sodium metasilicate, kerosene, carbon tetrachlorethylene, or, in the case of the high nickel alloys, a hot caustic solution. Following any of these treatments the surface should be washed thoroughly with water.

Following the water washing stainless clads should be washed with a warm 15% solution of nitric acid (130 to 150 F). Nickel, Monel and Inconel should be washed with a 10% solution of hydrochloric acid, also warmed to 130 to 150 F.

Rinsing in warm water should follow the acid wash, and then the surface neutralized with a 2% (by volume) solution of ammonia, followed by a thorough warm water rinse.



Clad steels are used for both the bottom and the shell of this brew kettle fabricated by Schock, Gusmer & Co., Inc., Hoboken, N. J. These parts are made of 10% nickel clad steel, while the outside of the shell is sheathed with Monel.



This assembly for use in a wind tunnel utilizes stainless-clad. Here stainless was used because it resists corrosion and because it can be polished smooth and keep air resistance to a minimum.

Applications of Clad Steels

Since the chief reason for being of clad steels is to serve in those applications where corrosion or heat, or both, tend to destroy less highly alloyed materials, this group of materials can be found in almost every industry where these factors are bothersome. In addition, certain clads are used where heat and corrosion are minor problems but where cleanliness is paramount. In still other circumstances certain clads are selected because of their ability to transfer heat, such as in various cooking applications where heat must be spread rapidly to avoid hot spots.

There seems to be little limit as to the type of equipment into which clad steel goes. It is used on fishing boats, naval vessels, home cooking utensils and kitchen equipment, tank cars, processing equipment of all types, ornamental architectural applications, tables, processing towers, tanks of various sorts, hospital equipment, water supply systems and hundreds of other places.

A better idea of the possible uses of clad steels may be gained by listing some of the products using clad steels according to industries:

Alcoholic Beverages — tank cars, storage and mash tanks, strainers, mixing vats, stills, battling equipment, fermentation tanks, and many others.

By-Product Coke Plants—centrifugal housings, tanks and evaporators, acid washing and caustic neutralization tanks, dissolving tanks, recovery tanks, processing tanks, absorber and aeration tanks.

Chemical — evaporators of many types; equipment for handling hydrochloric acid, sulfuric acid, tanks and tank car linings, stills, evaporators, steam chests, heat exchangers, reactors, filter bodies, pre-heaters, screw conveyors, evaporator pans, rotary dryers and vibrating conveyors.

Fatty Acids and Oils—distillation equipment, storage, neutralization and receiving tanks, jacketed kettles, bubble towers, condensors, fat splitting equipment and sulfonators.

Food Handling and Packing—Table tops, processing, dissolving and storage tanks, evaporators, milk pasteurization equipment, mixers, quick freezing equipment, jacketed processing kettles, tank cars, pressure cookers, crystallizer tanks, finishing pans, trawler fish holds, brine tanks and cooking kettles.

Glass and Ceramics—pottery furnaces, frit containers, etching and frosting equipment, washers and reboilers for concentration of hydrofluoric acid.

Heat Treatment of Metals—tanks for sodium nitrate treatments, carburizing tanks, hoods and retorts for nitriding.

Water Handling—penstocks, venturi tubes, dam gates and weirs, dam gate guides and face plates.

Leather — Press plates, rotary tan drums, evaporators, processing tanks.

Petroleum—Acid washing and caustic neutralization tanks, condensors and heat exchangers, batch stills, naphtha coolers, caustic soda regeneration equipment, cracking and fractionating towers, equipment for dewaxing furfural solvent, accumulators and separators.

Pharmaceuticals and Cosmetics—extractors, dryers, stills, processing and storage tanks, stripping stills, solvent storage and recirculation vessels, animal operating tables, sterilizers, table tops, autoclaves, pressure tanks, jacketed processing kettles, and fermenters.

Paper and Pulp — Digester shells, condensors, beaters, mixers, machine vats, board press plates, agitators, fourdrinier frames, tanks, caustic soda recovery equipment, leaching or dissolving tanks, vacuum washers, diffuser tanks and stills.

Textiles—All types of dyeing equipment, steeping presses, desulfurizing tanks, tank cars and storage tanks, autoclaves, churns, dry cleaning equipment, bleaching kiers, yarn twist setting and conditioning units, boil-off tanks and equipment for making synthetic fibers.

Varnish, Resins, Plastics, Etc.—Kettles, storage and dissolving tanks, tank cars, alkylation autoclaves, cooling troughs and molds, portable varnish kettles, stills, deodorization equipment, press plates, driers, reactors, impregnators, mixers and jacketed kettles.

Miscellaneous Equipment—Tobacco processing tanks and ordering drums; turpentine stills and dehydrators; wood distillation retorts; ester gum cooling pans; brine tanks for refrigeration equipment; agers for rubber products; spray drying equipment in manufacturing detergent powders; degreasing equipment for metal cleaning; side sheets in locomotive fire boxes and a wide variety of other types of equipment used in innumerable industries.

Most of the applications enumerated involve the use of steels clad with the various grades of stainless steels, nickel or high-nickel alloys. Silver clads are used, among other applications, for such products as reboilers and columns for hydrofluoric alkylation in the petroleum industry and for reboilers used in the concentration of hydrofluoric acid. The latter use is particularly important in the glass industry.

As can be noted by the types of equipment listed, most finished products made from clad steels are of relatively simple shape such as circular columns and tanks; rounded or square vessels of various kinds or long, open and flat surfaces.

Most of the applications mentioned up to this point have been industrial in nature. There is now a growing use of clad steels in the home products fields. Such uses include kitchen utensils, sinks, washing machines and equipment of a similar nature.

Listed another way, here is a comprehensive compilation of applications and fields of use for clad metals:

Accumulator towers, acid concentrators, acid storage tanks, air conditioning, architectural, autoclaves, automotive, aviation;

Back bars, barrels, bar tops, bleaching equipment, blow pits, bottling tables, bottling machines, brewing and distilling equipment, buckets, building trim, bumpers, canal lock gate seals, canopies, carbon absorption vessels, ceramic plant equipment;

Cereal cookers, cheese vats, clay emulsion tanks, coffee urns, coffee roasting equipment, condensors, conveyors, cooking vats and utensils, counters, cutting oil pans and conduit liners;

Decorative paneling, die jigs, diffusers, digesters, dining car equipment, display cases, doors, drums, ducts, dye kettles, elevator cars, evaporators, extractor cylinders, fermenters, filter units, flues, food processing equipment, frying pans, fume stacks;

Head boxes, heaters, heat exchangers and heat exchanger shells, homogenizers, hoods, hoppers, ice cream cabinets, ink tanks, jacketed vessels, kettles, kick plates, kiers, laboratory table tops and equipment, lacquer kettles, laundry equipment;

Marine equipment, mash tubs, milk storage, transporting and processing equipment mixing tanks, oil refinery equipment, operating tables;

Packing tables, paint and varnish equipment, paneling, pans, pickling tanks, pressure cookers, pressure vessels, processing tanks, pulp and paper machinery, radiator grilles, reels, refrigerated cabinets, resin kettles, retorts, river water conduits, rotary dryers;

Sewage disposal equipment, sinks and drainboards, smoke stacks, soap crutchers, soap frames, soap kettles, sorting tables, spatulas, steam tables, sterilizers, stills, storage tanks, stove tops, sugar equipment linings, synthetic rubber machinery, syrup drums and tanks;

Tank cars, textile equipment, towers, varnish plant equipment, vacuum pans, washing machines, waste liquor tanks, work surfaces, yarn dryers and yeast tanks.

Conclusion

Although clad steels and their uses are rather well known to engineers in a number of fields, there still seems to be considerable room for extension of applications.

The automotive industry uses little or no clad steel, at least on passenger cars. However there are volume applications which could logically be converted to clad steels. Bumpers, bumper guards and radiator grilles are the most obvious points of use. Railroad cars, both passenger and freight could probably make considerable use of the less expensive types of stainless clad.

Although production of clad steels for general sales is limited to a handful of companies, there are several other producers of engineering products who make clad steels for their own needs. Too, there are other companies planning to enter the business, some of which intend to specialize in sheet and strip and others in special combinations of clad materials. In the latter categories will be composite materials that will not meet the strict definition of clad steels, but which will offer special properties such as are not readily available in present day clad steels. Such combinations might include stainless steel and copper, or copper in combination with other corrosion-resistant materials.

At present there are some other materials which serve some of the requirements of clad steels, but which normally seek applications in quite different fields. Aluminum dip-coated steels is one such material; copper capped stainless steel is another.

In general, it now appears as though the clad steels have an extremely promising future, despite the fact that they are now widely applied.

Producers of Clad Steels

Alan Wood Steel Co., Conshohocken, Penna.
Allegheny Ludlum Steel Corp., Brackenridge, Penna.
Copperweld Steel Co., Glassport, Pa.
Granite City Steel Co., Granite City, Ill.
Ingersoll Steel Div., Borg Warner Corp., Chicago, Ill.
Jessop Steel Co., Washington, Penna.
Lukens Steel Co., Coatesville, Penna.
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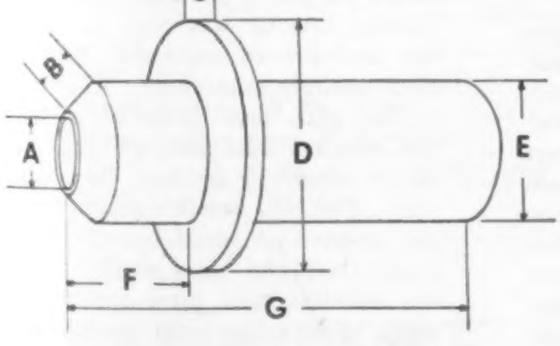

A—*Inside Diameter* . . . concentric with outside diameter.

B—*Chamfer* . . . right length . . . correct angle.

C—*Flange Thickness* . . . stout enough to take the thrust.

D—*Flange Diameter* . . . ample enough to distribute the load.

E—*Outside Diameter* . . . correct dimension for easy assembly.

F—*Flange Position* . . . to "locate" the bearing.

G—*Length* . . . held to right limits . . . sufficient to carry the load.

X—*Alloy*—Selected to suit operating conditions.

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Engineering Shop Notes

Drill Jig With A Window

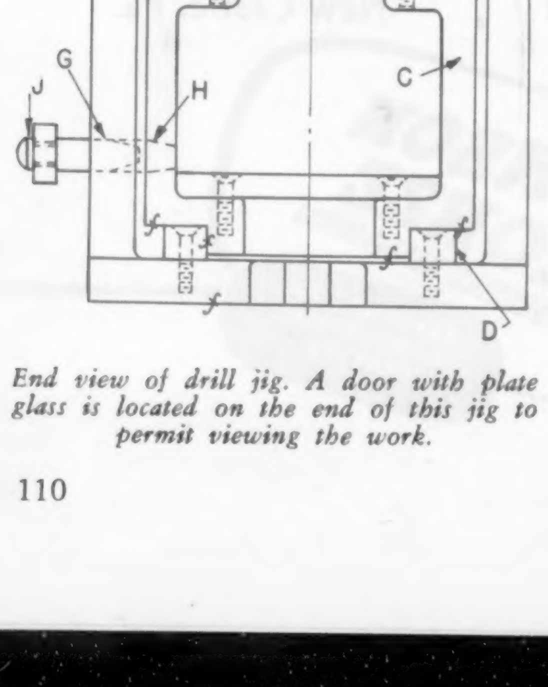
by Robert Mawson

Here is a box-type drill jig with several unique features including a window through which to watch the drilling operation. This tool was used for machining the casting "A" shown in the illustration.

The jig is made with a locating member "C" which slides on two machine steel tracks "D." When placing the piece into the jig this locating member is slid out of the body of the tool.

The piece is then placed over the locating member and positioned by a machine steel block which fits between the surfaces "B." The position longitudinally is determined by two pins; therefore, the location of the piece in the jig is determined by the surfaces sideways with the upper block and endways by the two pins.

Two shoulder headed screws "F" are then tightened down to hold the piece securely onto the locating surfaces. A portion of the shoulder of the screws has been removed so that it is only necessary to turn the screws 180 deg. to free the shoulder from contact with the piece.



End view of drill jig. A door with plate glass is located on the end of this jig to permit viewing the work.

With the piece located and held as described, the locating member is slid back into the jig body. The correct position of the locating member is determined by the tapered pin "G" which fits into a hole "H" in the locating member, this hole having been machined with a similar taper to that of the pin. The tapered pin is actuated with the lever "J" which moves the pin in or out as desired. The lever moves on a pin which is carried in a bracket fastened to the outside of the jig body. Between the lever and the jig body is placed a spring which tends to force the tapered pin into the machined hole in the movable locating member.

With the locating member and piece in the machining position, a ¾-in. hole is drilled and then reamed in the casting, the drill being guided through the slip bushing "K." With this bushing removed the top of the casting is spot-faced.

The machining operations are now completed and to remove the piece it is only necessary to reverse the operations of loading the fixture.

One of the bad features of a box-type or closed drilling jig is that the operator is unable to see the operations being performed, and in this tool a rather unusual feature has been introduced to counteract this disadvantage. A door which is made from a plate of glass is provided on the one end of the jig. With this feature when the jig is closed and ready for the machining operation the glass enables the operator to look into the drilling jig and see that the special tools are performing the desired operations.

In a leading paper mill, the fronts of rotary soda mill incinerators were formerly made of plain cast iron. They are not protected by brickwork and are exposed to heat from the oil burners. By the adoption of an iron containing upward of 1.50 nickel and 0.5% chromium, life of these castings was increased from 1 to more than 2 years.

—From "Nickel Cast Iron News"

Moisture in chlorinated and sulfuric cutting oils may cause failure of the cutting edge of cemented carbide tool tips. Moisture weakens the tip by attacking the cobalt binder.

— From a report prepared by Watertown Arsenal, issued by Office of Technical Services

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Electric Furnace Brazing Solves a Problem

by Stephen Porter Lathrop

In making five distinct welds in an assembly job consisting of four small stainless steel tubes inserted in a stainless piece which in turn is inserted in a brass outer shell, the Wooster Brass Co. of Wooster, Ohio, found that one weld would be melted while another was being done.

Using the torch method of making the weld rejects ran from 40 to 45%, chiefly in the form of leaky joints where the small stainless steel tubes were welded to the stainless steel piece that was inserted in the brass outer shell. Electric furnace brazing was tried on the assembly, and proved successful. Rejects have been entirely eliminated.

The plan now followed is to insert the stainless steel part which is about ½ in. by about ½ in. into the brass outer shell. The four small stainless steel tubes are inserted in small holes in the brass outer shell and into small openings in the stainless steel piece inserted in this shell. Silver solder rings are then put over the four tubes in position of welding. A larger silver solder ring is put around the stainless steel piece that is inserted in the brass outer shell.

This entire assembled unit is then placed in the electric furnace that has been heated to 1450 F. Inasmuch as the silver solder melts at 1200 F, the entire assembled unit is heated at one time to 1450 F, thereby producing five welds simultaneously. The assembled unit is left in the electric furnace for 15 min., which produces the five required welds. Besides doing a perfect job without rejects, the electric furnace idea does the job in half the time required for welding each weld individually with the torch.

MATERIALS & METHODS Engineering File Facts

NUMBER 147
September, 1947

MATERIALS: Properties

Seizing of Certain Metals at 750 F

Key
O = Do Not Seize
X = Seize
* = Revolutions to Seizure

		1 Low Silicon Cast Iron	2 Nickel-Chromium Cast Iron	3 Nickel Cast Iron	4 Nickel Cast Iron	5 Ni-Tensyliron	6 Ni-Resist	7 Monel (Rolled)	8 Stainless Steel	9 Nitrided Steel	10 "S" Monel	11 Cyclops Steel	12 Cast Cyclops Steel	13 B.T.G. Steel	14 Rolled Nickel	15 Cast Nickel Copper Alloy	16 Nickel Brass	17 Plain Rolled Steel	18 Plain Cast Steel	19 Cast Chromium Steel	20 Cast Tungsten Steel	21 Chrome Plated Steel
Low Silicon Cast Iron, 1.10 Si	1	O	O	O	O	O	O	O	O		O											
Nickel-Chromium Cast Iron, 2.7 Ni—.5 Cr	2	O	O	O	O	O	O	O	O		O											
Nickel Cast Iron, 4.0 Ni	3	O	O	O	O	O	O	O	O		O											
Nickel Cast Iron, 3.5 Ni	4	O	O	O	O	O	O	O	O		O											
Ni-Tensyliron, 2.15 Ni	5	O	O	O	O	O	O	O	O		O											
Ni-Resist	6	O	O	O	O	O	O	O	O		O											
Monel (Rolled)	7	O	O	O	O	O	O	35*	X	O	X				X	45*	3515*			O	O	O
Stainless Steel, 12 Cr	8	O	O	O	O	O	O	X	205*	O	X	X	X		X	113*	1674*		O	O	O	O
Nitrided Steel	9							O	O	O		O	O	O			O	O	O			O
"S" Monel	10	O	O	O	O	O	O	X	X		O											
Cyclops Steel, 20 Ni—8 Cr	11								X	O												
Cast Cyclops Steel, 20 Ni—7 Cr	12								X	O												
B.T.G. Steel, 60 Ni—12 Cr—3 W—1Mn	13									O												
Rolled Nickel, .09-.29 C	14							X	X						X					O	O	
Cast Nickel-Copper Alloy, 30 Ni—63 Cu	15							45*	113*													
Nickel Brass, 5 Ni-	16							3515*	1674*	O							O					
Plain Rolled Steel	17									O								X		O		
Plain Cast Steel, S.A.E. 1040	18								O	O												
Cast Chromium Steel, .65 C—18 Cr	19							O	O						O			O				
Cast Tungsten Steel, 13 W—2 Cr	20							O	O						O							
Chrome Plated Steel	21							O	O	O												O

Tests upon which these data are based were conducted by N. L. Mochel, Westinghouse Electric Corp., Philadelphia. Publication is by permission of Westinghouse Electric Corp. and International Nickel Co.

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MATERIALS & METHODS Engineering File Facts

NUMBER 148
September, 1947

MATERIALS: . . Finishes
METHODS: . . Testing

Adhesion Testing of Organic Coatings

Adhesion is defined simply as the property which causes one substance to stick to another. Although it is not quite as elusive a property as hardness, adhesion too can be determined in a variety of ways through the use of widely different implements and procedures.

Test	Description
1. Chisel Adhesion Test	A chisel under definite load is caused to bite into the film at a fixed angie. The test panel is drawn against the edge of the chisel by means of a distended spring, the tension of which diminishes until it is insufficient to separate the film from the panel. A time-tension curve is recorded on a rotating drum.
2. Cross-Cut Adhesion Test	A series of parallel cuts are made through the film in one direction, and another series is cut at right angles to it. Results are expressed by counting the number of squares from which the paint has scaled, or by counting the squares left intact.
3. Courtney and Wakefield Method	The coating is applied to thin foil, dried, and then cemented to 18-gage steel panel. The use of a constant speed motor, a movable spring balance, a pen and a chart allows for graphic representation of the strength required to rupture the bond.
4. Erichsen Film Test	Test panel is clamped horizontally and then indented with a steel ball under applied pressure. Results are indicated by the distance the ball travels, and its corresponding effect on the film.
5. Gardner Laboratory Method	Silk cloth is placed on tacky film and pressed firmly by means of a spatula. After complete drying, surface is razor cut into areas 1-cm. wide. The panel is then placed in tensile testing machine and the individual strips are removed under regulated load.
6. Gelva Method	A film about 2 mils is spun and dried on a plate glass disk. A spot on the surface is softened with acetone and a metal plug is set on the sticky spot. The acetone is then dried out in an oven. The plug is bored so that a loose fitting pin may be inserted and weights applied.
7. Hart Impact Tester	Test panel is clamped to base with rubber sheet in between acting as shock absorber. The hammer is raised to a vertical position and then dropped. Adjustment of height at pivoted end of hammer allows for vertical or glancing blows.
8. Liquid Jet Test	A jet of water or other liquid is directed at the angle formed by the edge of the coating and the test panel. The jet is usually flat, about ⅛-in. thick and is directed at an angle of 45°.
9. Liquid Wedge Test	A small hole, drilled through the middle of the metal panel, is covered with a small sheet of metal foil; the panel is then painted, dried and placed in test position so that mercury under high pressure may be forced against the foil.

Test	Description
10. Mandrel Test-Rod	Test panels are bent over rods of varying diameters, and results are reported by indicating observation of film after testing with specific rods.
11. Mandrel Test-Cone	Test panel is bent around a cone shaped tool so that the coating is elongated at increasing values from the base to the narrow end. Coating is observed after test as in rod method.
12. Nettman Test	Base material is made in form of cylindrical mandrel. The force required to drive this mandrel through a tubular opening which is a sliding fit for the uncoated mandrel is the measure of adhesion.
13. New York Production Club Method	Test panel strips are glued to small wood blocks so that only 1 sq. in. of surface is in contact. They are then pulled in regular tensile strength machine, so that force is applied in the plane of the film.
14. N. Y. Production Club Improved Knife Test	A knife blade, located between the wheels of a four-wheel rack, is set by spring pressure until enough force is exerted to lift film. The instrument is then pushed forward and readings are taken of horizontal thrust required to lift coating.
15. Repeated Impact Test	A coated panel is subjected to repeated blows by a case hardened steel hammer. Impact value is defined as the number of impacts required to expose base panel.
16. Rossmann Tests (1)	Adhesion is determined as a time function of the power necessary for splitting off coating, by means of a wedge-shaped tool.
(2)	A ball, 1 mm. in dia., is forced at a speed of 5 cm. per sec. over the surface with gradual increase in pressure. When scratch is made the pressure is recorded by an electrical contact.
17. Schmidt Adhesion Test	Similar to the Gelva Method. Small blocks of wood are cemented to the coating and dried under pressure. Vertical pull is then applied.
18. Shellac Undercoat Adhesion Test	This test is recommended for synthetic resin varnishes. The clear varnish is applied over a shellacked panel, dried and then tested with a pen knife.
19. Swinging Pendulum Test	A wood block is glued to the coated surface and the panel is fixed so that the block will be struck by the pendulum at its point of greatest velocity. The difference in the angular swing of the pendulum before and after fracture of the bond is the measure of adhesion.

Prepared by George Black

MATERIALS & METHODS

DIGEST

A selective condensation of articles — presenting new developments and ideas in materials and their processing — from foreign journals and domestic publications of specialized circulation.

Edited by H. R. CLAUSER

A New Mechanical Joining Method

Condensed from "Sheet Metal Industries"

If planned production is to be used to the fullest extent in certain phases of sheet metal fabrication, a new type of joint is needed to overcome some of the disadvantages of riveting and welding thin material. A new mechanical joint formed as an integral part of the sheet, known as the Cookson lock joint, has been evolved for this purpose.

The lock joint consists essentially of two parts, comprising a spring clip section formed on the edge of one piece of metal and a lock section formed on the edge of the corresponding piece. The joint is assembled by pushing the lock portion into the clip by hand pressure. The lock is thus snapped into position and gripped securely by the engagement of the lips. For disengagement the lock is slid out of the clip longitudinally.

The manufacture of the clip and lock sections is easily and efficiently carried out on a lock forming machine which is essentially an adaptation of an ordinary type of folder incorporating suitably shaped form bars. The assembly of the components obviously requires no tools or jigs. Therefore, it is immaterial for many purposes whether the articles are factory assembled or put together on the site by unskilled labor. All components can be completely finished before assembly.

Articles so assembled are extremely robust as the joint forms a column of considerable strength. Since the column is on the inside, the joints have a smooth finish on the exterior. Owing to the spring construction, the joints have controlled resilience. They are able to move under temperature changes and also tend to absorb sound vibrations.

In the field of packaging, great opportunities are present for the design of articles which can be assembled, packed, transported and returned unassembled after emptying, thus saving storage space in transit. Partition walls for buildings and ventilation air ducts can be made efficiently by this method. (W. Cookson. *Sheet Metal Inds.* (British), Vol. 24, May 1947, pp. 985-988, 998.)

Bearing Metals for High-Speed Diesel Engines

Condensed from "Metal Industry"

The use of tin and lead base white metals in diesel engine bearings is limited by their low compressive and fatigue strengths at operating temperatures. Otherwise, they combine the desirable properties to an extent not possessed by any other bearing metal so far developed. To extend their useful range, the lining thickness may be reduced. There is, however, a lower limit because of manufacturing difficulties; also, filtration must be improved as the thin linings can no longer embed foreign particles. In practice, a compromise has been struck with linings about 0.010-in. thick.

Cadmium - nickel and cadmium - silver-copper bearing metals would seem to fill the gap between the white metals and the stronger bearing metals. Practically, this does not seem to be true. The only case where the cadmium alloys have shown definite advantages over the white metals is a floating big end bearing in a V.8 engine.

Aluminum base alloys require hardened shafts. Their mechanical strength is low so they tend to lose interference fit. The results with steel shells lined with aluminum alloys were not promising.

Lead bronze with 20% lead is not ideal for main and big end bearings as it lacks mechanical strength and requires a crankshaft over 500 Brinell. The 30% lead-copper alloy is weak and must be bonded to steel shells. The bearing has a high load carrying capacity of fatigue strength at elevated temperatures but is not so tolerant of dirt or soft shafts. Steel crankshafts over 270 Brinell should be used.

Diesel engine big end bearings have been used with crankshafts of only 210 Brinell but the lead-copper bearing surface was coated with a thin film of pure lead to facilitate the running in. A 40% lead-copper alloy is being used in Diesel main and big end bearings. Lead coating is no longer necessary although it is a wise precaution with very soft crankshafts or very high speeds.

Indium plating has been adopted to protect cadmium base alloys from oil corrosion. It is also effective for lead plated lead-copper alloys. A lead-tin alloy with about 3% tin is equally resistant.

Where harder crankshafts are needed, alloy steels are usually required. Hard chromium plating is not completely satisfactory. Spraying with 0.7% carbon steel is satisfactory for white metal bearings but not for lead-copper bearings. Graphitic cast iron crankshafts are quite outstanding with lead-copper lined bearings.

Silver bearings with lead-indium plating have performed well in American aircraft engines. However, the important distinction between the silver and the lead-copper bearings is that the former depends for its functioning on the lead-indium film whereas the latter does not.

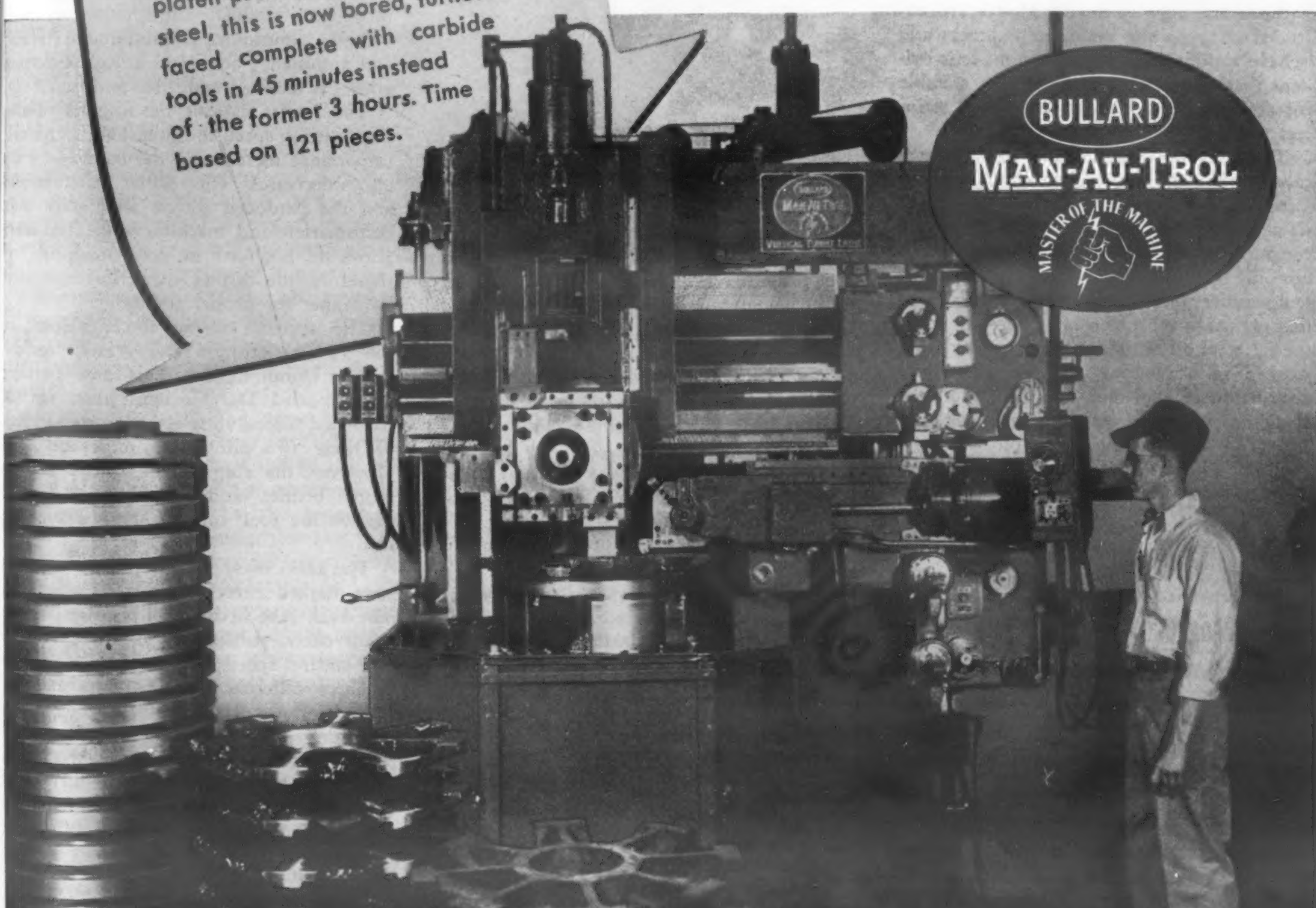
The lead-copper lined bearing requires steel shells but with white metal linings a wide choice exists. For high-speed Diesel bearings, the choice lies in general between steel and bronze, with the former becoming more widely adopted. (P. T. Holligan. *Metal Industry* (British), Vol. 70, May 23, 1947, pp. 375 - 377; May 30, 1947, pp. 402 - 404; June 6, 1947, pp. 419 - 420.)

Stainless Steel Tubes by Extrusion

Condensed from a Paper of the American Society of Mechanical Engineers

The extrusion method, well known for a rather long time in its application for nonferrous metals and alloys as copper, aluminum, magnesium and its alloys, has only lately been developed for dealing with stainless steel, special steel, and nickel alloys. These materials have to be extruded at high temperatures up to 2400 F, and require fast-working presses and high-quality wear- and heat-resisting tools.

Horizontal presses of the double-acting type make it possible to extrude solid billets into tubes in one operation. To prevent the metal from getting welded onto the mandrel, a loose head placed on the mandrel point is being used. This head pierces a slightly larger hole in the billet than the inside diameter of the tube, allowing the mandrel to enter the pierced billet without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MASTER OF THE MACHINE

DIGEST

stripping off the lubricant. The loose head drops from the mandrel just behind the die, together with the piercing discard.

Development took place when the International Nickel Co. started a 4000-ton double acting press during 1943. Since then this press has been used to extrude billets of 7- to 12-in. dia. into tubes of 3- to 8-in. O.D. Although normally Monel, Inconel and nickel are extruded, many trials have been made with stainless steel and also with special steel billets, some consisting of materials which were difficult to transform into tubes by any other known method.

This plant also made it possible for the first time to produce economically large-sized tubes from solid billets by using the so-called cupping method. Whereas during piercing of the billet the die is normally open, in the new method the die is closed so that the metal backfills the container. Only a thin disk of metal is left between the mandrel head and the closing plate, and this is punched through the die by means of the advancing mandrel after the closing plate has been removed.

Since stainless steel and Monel are extruded at about the same temperatures and behave similarly during extrusion, it is evident that this new method is quite suitable for the manufacture of large tubes in stainless steel.

The conversion of a solid billet into a tube by the extrusion method consumes only a few seconds, during which time no change in temperature takes place. There are a considerable number of special alloys which can only be hot-worked within a very narrow temperature range, and it is in this field that extrusion must step in. There are other special steel alloys which crack when being worked in a piercing mill owing to the destruction of the fiber structure, and here also the extrusion method may be the answer. (Hugo Lorant. Paper No. 47-SA-9, *Am. Soc. Mech. Engrs.*, June 1947 meeting, 4 pp.)

Progress in Zinc Plating

Condensed from "Metal Treatment"

In recent years substantial progress has been made in the application of zinc plating as a protective treatment for steel, either alone or as an under-coating for chromium. During the past ten years it has become possible to produce bright zinc coatings. The higher current densities permit thicker coatings to be deposited in a given time. One of the most important recent introductions is a cyanide solution with increased throwing power which gives a white, fine grained deposit.

The development of the passivation process for zinc has brought it into open competition with cadmium. With the present electrodeposits of zinc and the passivation process, there is little to choose between the two in terms of corrosion resistance. If anything, the balance probably favors zinc for industrial atmospheres.

A further development of the method of plating zinc base die castings directly with chromium has made it possible to combine the corrosion resistance of zinc with the decorative features of chromium. The steel is plated with zinc, then with chromium. The cost is much less than the more widely used process with copper or brass and nickel undercoatings. In order to obtain the best results, the zinc deposit should be as free from porosity as possible.

Chromium deposited directly on a zinc coating gives better results measured over a year than are shown when an intermediate layer of copper, brass or nickel is used. For practical purposes, there seems to be no doubt that 0.0004-in. zinc is preferable to double the thickness of nickel as an outdoor decorative finish if both are chromium plated.

In general, zinc plating of steel followed by passivation gives an excellent rust resistant finish. Bright zinc plating covered by transparent lacquer is fairly cheap and effective. Chromium plating direct on to zinc base alloys offers the greatest scope to newer and simpler forms of decorative plating. (W. F. Coxon. *Metal Treatment* (British), Vol. 14, Spring 1947, pp. 38-40.)

A New Casting Resin

Condensed from a Paper of the National Bureau of Standards

Many casting resins have been developed, but few have the vital electrical properties for proper operation of high-impedance, high-frequency equipment. A new casting resin embodying the required properties of mechanical and electrical stability has been formulated at the National Bureau of Standards. Various applications at the Bureau indicate that, with slight modifications to suit the intended use, the new potting compound can be employed in many high-frequency devices requiring such mechanical-electrical insulation.

The most important properties specifically desired of a casting resin when utilized at high frequencies in high-impedance circuits are low power factor, low dielectric constant, short polymerization period at low temperature and atmospheric pressure, high impact strength, small volume shrinkage on polymerization, dimensional and electrical stability, and low moisture absorption. By copolymerizing and by adding polymers as fillers to monomers, however, a number of suitable casting resins were produced.

Following are some of the typical mechanical and electrical properties of the casting resin:

Compressive strength, psi.	17,100
Izod impact, ft. lb./in. of notch	0.228
Coefficient of thermal expansion per °C	11 x 10^{-5} (approx.)
Heat distortion °C	68-70
Power factor (at 100 mc. and 50% RH)	0.0004-0.0008
Dielectric constant (at 100 mc. and 50% RH)	2.5
Dielectric strength (1/16-in. sample; volts/mil)	610-660

The special features of the resin make feasible many new applications of electronic devices. By rigidly embedding electronic circuits or even complete plug-in sub-assemblies, the compound provides excellent electrical insulation as well as protection against rough handling and deteriorating atmospheric conditions. It is particularly well adapted for use with subminiature electronic equipment built by the printing techniques.

The resin should be especially useful in high-impedance control devices in heavy industry to provide adequate protection against such conditions as vibration, acid fumes, high humidity, and salt spray. Other potential uses include the potting of components and subassemblies for radar equipment, hearing aids, portable radio transmitters and receivers, and numerous subminiature electronic control devices. (P. J. Franklin & M. Weinberg. Paper, *Nat. Bur. Standards.*)

Machining Light Alloys

Condensed from "Revue de l'Aluminium"

Because light alloys have such good machinability, the influence of various factors on their machinability has not been thoroughly studied. Lathe tests were made on 99% aluminum, Duraluminum (regular and annealed), and 10% silicon-aluminum alloy (as received, stabilized and hardened).

The results indicate the importance of a high cutting speed for aluminum alloys; this importance increases as the hardness of the alloys decreases. The regular Duraluminum and the hardened silicon alloy show little deformation and machine well. The other alloys do not have as good machinability; therefore, the cutting speed for them must be higher for proper results.

The specific cutting force is least for the 99% aluminum and greatest for the regular Duraluminum. This force is greater for annealed Duraluminum than for the hardened silicon alloy although the strength of these two alloys is almost the same. However, the chip of the silicon alloy is more brittle; consequently, its friction against the tool and the cutting force are less.

The ratio of feed to depth of cut has a very marked effect on the required power. The back rake of the tool also has a significant effect, particularly at low hardnesses and cutting speeds.

Three different types of chips and machined surfaces are found, depending mainly upon the speed. The best finish is obtained with speeds over about 1640 fpm. and sufficiently large back rakes. In the case of the silicon alloy, the chips differ quite appreciably from one condition to another.

The surface finish is better for the hardened material than for the other conditions.

The tool wear was not determined precisely but high-speed steel tools failed rapidly at speeds over 1970 fpm. for the Duraluminum and 985 fpm. for the silicon alloy. Sintered carbide tools with their better wear resistance would therefore be valuable at the high speeds necessary to obtain a good surface finish. (R. Schweyckart. *Rev. l'Aluminium* (French), Vol. 24, Feb. 1947, pp. 44-56.)

Applications of Tantalum in Electronics

Condensed from a Paper of the Electrochemical Society

The application of tantalum in electronics has been chiefly as anode and grid material in transmitting tubes, particularly in types that must withstand high operating temperatures and still higher processing temperatures, must operate at high voltages and must meet high performance requirements. Operating temperatures for anodes range from approximately 1200 to 1850 F.

As a member of Group V-A in the periodic table, tantalum in the elemental form has the properties of a metal and in its compounds many of the properties of a nonmetal. The high melting point of tantalum and its reactivity at high temperatures dictate the powder technics that are employed in its metallurgy. The metal is obtained as a crystalline powder by electrolysis of a fused K_2TaF_7 bath. The powder is pressed into billets and then sintered in a high vacuum. An extremely pure product is obtained by the sequence of operations; metallic impurities and carbon may be present in amounts up to 0.05%.

The melting point of tantalum is 5425 F, at least 1830 F above processing temperatures and 3030 F above normal operating temperatures. There is no embrittlement due to equiaxing or phase changes so that the structural strength of a tantalum element does not deteriorate.

Tantalum is unique among the high melting refractory metals used in tube construction in the ease with which it may be fabricated. It can be worked as readily as nickel. It can easily be spot or seam welded and the welds are as ductile and workable as wrought metal. It can be stamped, spun, or deep drawn. Although it cannot be cast by any known commercial technics, a variety of structural shapes is made possible by its availability in different forms of wire, sheet and tubing, both seamless and welded.

Tantalum, because of its chemical inertness, can be cleansed by a variety of reagents

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without attack. Dirt, grease fingerprints and metallic deposits from welding operations can be completely removed. When steel grit is used for roughening the surface, it can be dissolved in acid. The outgassing operation can therefore be shorter than when materials are employed which are not as susceptible to rigorous cleaning. If the design of the tube permits outgassing at high temperatures, the tantalum parts will become gas free and the volatilization of the tantalum during operation will be practically nil. (L. F. Yntema & R. W. Yancey. Paper, *Electrochemical Soc.*, 4 pp.)

Developments in the Applications of Controlled Atmospheres

Condensed from "Metallurgia"

The various types of atmospheres are now fairly well standardized. In Britain they include those derived from synthetic ammonia and from the controlled combustion of a hydrocarbon gas. Controlled atmosphere generators are compact units and, generally speaking, are automatic. With some modifications, modern controlled atmospheres can be used in older furnaces but this can be only an unsatisfactory compromise and, in the long term view, uneconomical.

The fields of application include processes which require the maintenance of the original surface finish and composition (bright annealing, bright or clean hardening and tempering of steels with freedom from decarburization, patenting); processes which require the chemical modification of the surface (carburization of steel, malleablizing of white cast iron for white heart malleable) and novel processes (nitriding, deoxidation of hot rolled strip, sintering).

Economically, the use of a controlled atmosphere has many attractive features: elimination of subsequent cleaning, material saving by elimination of scaling and cleaning losses, elimination of containers and packing materials resulting in a fuel saving, saving in floor space, and improved working conditions. There are also other advantages such as low maintenance cost, smaller labor charges, and better quality of the product.

There are many problems of practical as well as academic interest awaiting further study. There is need for fundamental research on the physical chemistry of the generation and purification of controlled atmospheres, especially for specific requirements. There is much scope for further development of furnaces. Fundamental study is needed on the effect of industrial controlled atmospheres on the high temperature strength and corrosion resistance of

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the heat resisting materials used in furnaces.

Within the field of bright annealing, there are many problems, including the effect of the atmosphere on the mechanical properties of low carbon steel, the poor tinning and galvanizing properties of bright annealed surfaces, commercial bright annealing of yellow brass, the adverse effect of rolling lubricants on the surface finish, the annealing of silicon iron for transformer sheet, and the production of protective oxide films on alloys by selective oxidation. (I. Jenkins. *Metallurgia* (British), Vol. 36, May 1947, pp. 23 - 27.)

Chromium-Base Alloys for High Temperature Service

Condensed from a Paper of the National Advisory Committee for Aeronautics

One of the objectives in the metallurgical research on heat resisting metals for gas turbines has been the development of alloys that could operate at high temperatures under stresses similar to those permissible at room temperatures. The very high strength exhibited by chromium-base alloys (55 chromium, 25 iron, 20% molybdenum and 60 chromium, 25 iron, 15% molybdenum) in rupture tests at 1350 F indicates that they are potentially among the most promising known for bucket service in gas turbines.

Chromium-base alloys were tested that had rupture strengths as high as 73,000 and 54,500 lb. per sq. in., respectively, for fracture in 100 and 1000 hr. The highest similar values published for other alloys are in the order of 50,000 and 40,000 lb. per sq. in. A strong precipitation reaction occurs at 1350 F which is stable at that temperature and is probably responsible for the high strength.

The chromium-base alloys have certain rather severe limitations in their present state of development. The most serious are brittleness at room temperature and the necessity for melting and casting under high vacuum to avoid the detrimental effects from the oxygen and nitrogen in air. Considerable progress has been made in overcoming these difficulties, and further improvement seems quite possible.

At the present time the alloy most promising for service at 1350 F appears to be a 60 chromium—25 iron—15% molybdenum alloy with less than 0.05% carbon and 0.5 to 0.7% silicon. This alloy has the best combination of strength at 1350 F and engineering properties at room temperature. It can be machined and processed in the chill-cast condition, *with care,* in the normal

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manner. Higher strengths can be obtained from alloys with higher molybdenum contents, but at the present time their inferior properties at room temperature offset their higher strength. (J. W. Freeman, E. E. Reynolds & A. E. White. Tech. Note No. 1314, *National Advisory Committee for Aeronautics*, 21 pp.)

Steel for Plastic Molds

Condensed from "Iron and Steel"

Since in the manufacture of plastic products molds are an important consideration, considerable work has been spent on the development of mold steels. Complicated molds are machined while simpler molds can be hobbed. Molds must resist pressures of 3,000 to 12,000 psi., temperatures up to 450 F, abrasive action and, in some cases, corrosion. A high polish is required on the finished molds. Hard chromium plating has been used to give this finish, but does not find universal application.

The requirements to be satisfied by mold steels are: reasonable machinability, surface hardnesses of 59 to 60 Rc, core strengths of 157,000 to 224,000 psi. with maximum impact resistance, clean hardening, minimum distortion in hardening and convenience of handling. In addition, the annealing treatment must be simple so the design of molds can be easily modified.

The steels for molds may be nickel-chromium or nickel-chromium-molybdenum steels for either direct oil or air hardening, or for carburizing or cyanide hardening; or they may be direct oil or air hardening die steel such as the high carbon, high chromium type. In some instances good quality carburizing mild steel can be used for simple molds for short runs. The nickel-chromium and nickel-chromium-molybdenum steels are the most widely used because they most nearly satisfy the requirements.

The hobbing process is mainly used in the production of multiple cavity molds and small molds for plastic moldings of simple outline. Although it has several drawbacks, the tool room costs for mold production are considerably lower than for other methods of mold production. The stresses the master hob is capable of withstanding limit the mold material to special plastic hobbing steels, some carburizing steels and Armco iron.

The hardness of the material to be hobbed should not exceed about 140 Vickers but the ease of hobbing must not interfere with the production of a durable mold. After hobbing, the mold is heat treated.

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British and American manufacturers appear unanimous in the selection of the high carbon, high chromium type of die steel for master hobs with the alternative choice of a high carbon, high manganese die steel. (E. T. Gill & G. N. Gee. *Iron & Steel* (British), Vol. 20, May 1947, pp. 185-188.)

Magnesium-Zirconium Alloys Offer Outstanding Properties

Condensed from "Metallurgia"

Although magnesium alloys have been accepted for more than 20 years, scarcely any new alloys of outstanding merit have been developed during this time. In 1938 and 1939 it was found that zirconium exercises a most intensive grain refining effect on magnesium and as a result the physical and mechanical properties are greatly improved.

Despite these apparent benefits the problems of effectively and economically introducing it were not easily solved. Not only was it difficult to introduce and maintain the requisite quantity of zirconium, but trouble was encountered with flux inclusions. Fluorides have finally proved to be the most satisfactory means of introducing the zirconium. Of the many methods to overcome the flux inclusions, the only real improvement was that of settling under a favorable temperature gradient. Special high-density fluxes of the inspissated type were developed which made possible the commercial production of completely flux-free alloys.

In the cast state, with a simple heat treatment, 0.1% proof stress figures of 22,400 psi. and, in the wrought state, 44,-800 psi. can readily be obtained with the zirconium alloys. Impact values, resistance to notch sensitivity and fatigue characteristics are good. Moreover, the corrosion resistance is much better than the best of the present normal purity alloys and compares favorably with that of the high purity materials.

Wrought zirconium alloys have outstandingly good mechanical properties and are more easily hot worked than any of the present alloys. Wrought Elektron ZZ contains 0.5 to 1.0% zirconium, 1.0 to 5.0% zinc and up to 4% cadmium. The greatly improved workability is attributed to the intense grain refinement. These alloys can be extruded over a wide temperature range at very high speeds. They can also be rolled

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with steel mill practice. Forgings can be made by hydraulic pressure or impact.

The most suitable alloy for high strength castings (Z5Z) contains 4.5% zinc and 0.6 to 0.7% zirconium. The mechanical properties may be improved by a low temperature treatment, such as 24 hr. at 355 F. No work has been done on die castings, but this alloy may be used for permanent mold castings. A casting alloy developed for high temperature work (MCZ) contains 3% mischmetal as well as 0.7% zirconium. The chief virtue of this alloy lies in its high creep strength at temperatures up to 390 F.

This pioneer work proves that zirconium alloys can be regarded as a major development in the magnesium field. (C. J. P. Ball. *Metallurgia* (British), Vol. 35, Jan. 1947, pp. 125 - 129; Feb. 1947, pp. 211 - 214)

Photo-Electric Pyrometer for a Small High-Frequency Induction Furnace

Condensed from "Journal of the Iron & Steel Institute"

Immersion pyrometers utilizing platinum-rhodium thermocouples have been used for some years on a 100-lb. induction furnace used chiefly for melting Alnico type permanent magnet alloys. Because of the small size of the furnace, however, large rates of temperature change frequently occur. Therefore, it is most desirable to have a continuous indication of the temperature. Since it was found impracticable to employ a continuously immersed thermocouple, a photo-electric pyrometer was installed.

The pyrometer, simple in construction, uses a selenium barrier-layer photo-electric cell. The lens focuses a small patch of the metal surface onto the cell, the output of which is measured by a microammeter calibrated in degrees Centigrade.

The accuracy depends entirely on the nature of the metal surface. The alloys in question give extremely good surface conditions. Comparisons of the photo-electric pyrometer readings and the true temperature as measured by the quick-immersion thermocouple showed that the former will measure the true temperature within ± 18 F. A few results on other alloys gave a lower order of precision.

The photo-electric pyrometer has been in continuous use for about two years. The maintenance has been almost negligible, being confined to brushing away accumulated dust and the occasional replacement of the photo-electric cell or a badly splashed lens. (T. Land & H. Lund. *Iron & Steel Inst.*, (British), Vol. 156, May 1947, pp. 75 - 77.)

BOOK REVIEWS

Reference Data on Plastics

MODERN PLASTICS ENCYCLOPEDIA. *Published by Plastics Catalogue Corp., New York, 1947. Plastic, 9 x 11 in., 1556 pages in three volumes. Price $8.50.* This encyclopedia, an outgrowth of the former Plastics Catalogue, represents the eleventh annual compilation of technical data on the fast growing field of plastics. Of the 1556 pages, 720 are of editorial material, both technical and reference. The remaining pages are devoted to the advertising of plastics producers and fabricators and of equipment manufacturers. Dividing the work into three volumes makes for much easier use, particularly when referring to the many larger tables presented.

Volume I is devoted to up-to-date data on all of the plastics materials including laminated wood, with special reference, of course, to the newer developments. The researcher will find considerable value in a selected bibliography on German plastics.

Volume II is given over to the processing of plastics from the user's standpoint and sections therein include information on design, casting, finishing and assembly, as well as on plant and tool room equipment. The popular directory section, covering suppliers, fabricators, trade marks and trade names is contained in this volume.

Volume III contains 10 comprehensive charts. The charts cover, among other things, plastics properties, solvents, adhesives, chemical formulae, coatings, and the properties of synthetic rubbers and fibers.

High Frequency (Electronic) Heating

THEORY AND APPLICATION OF RADIO-FREQUENCY HEATING. *By G. H. Brown, C. N. Hoyler & R. A. Bierwirth. Published by D. Van Nostrand Co., Inc., New York, 1947. Cloth, 6¼ x 9¼ in., 370 pages. Price $6.50.* The authors of this highly technical work, Messrs. Brown and Hoyler, are research engineers in the RCA Laboratories at Princeton, N. J., and Mr. Bierwirth, formerly a research engineer in the same laboratories, is chief engineer for Sound Incorporated, Chicago. A volume, coming from such a

source, is produced with authority and experience back of it.

It is stated by the authors that the preparation of this volume has been prompted by the many questions they have received from engineers who are skilled in their profession but who are not familiar with radio-frequency phenomena. Another factor in its preparation is the realization that the technical literature concerning the basic principles of radio-frequency heating is decidedly scarce. These principles are fully discussed in the 24 chapters of the volume.

The authors express the hope that this volume will prove helpful to industrial engineers who may use radio-frequency generators in solving their heating problems and that it will be of benefit to those radio engineers who must inevitably become the exponents of a new industrial tool.

The book is splendidly enlivened with 264 illustrations, all the photographs having been taken by the staff photographer of the RCA Laboratories. It should have wide acceptance in this field.

Other New Books

A.S.T.M. STANDARDS 1946. PART I-A, FERROUS METALS. *Published by American Society for Testing Materials, Philadelphia 3, Pa., 1947. Cloth, 6¼ x 9¼ in., 1181 pages. Price $8.00; to A.S.T.M. members $6.00.* There are now more than 1400 standards, specifications, tests and definitions in the 1946 Book of Standards, covering nearly 7000 pages. As a result the book has had to be issued in five separate parts. Part I-A is the most widely distributed section. It contains about 225 specifications and tests, some 150 of which relate to steel and steel products.

A.S.T.M. STANDARDS 1946. PART I-B, NONFERROUS METALS. *Published by American Society for Testing Materials, Philadelphia 3, Pa., 1947. Cloth, 6¼ x 9¼ in., 917 pages. Price $8.00; to A.S.T.M. members $6.00.* Contains almost 200 specifications and tests, both standard and tentative.

A.S.T.M. STANDARDS 1946. PART II, NONMETALLIC MATERIALS, CONSTRUCTIONAL. *Published by American Society for Testing Materials, Philadelphia 3, Pa., 1947. Cloth, 6¼ x 9¼ in., 1762 pages. Price $12.00; to A.S.T.M. members $9.00.* This is the largest of the "standards" volumes, made up of over 300 specifications. Over 30 groups of standards are involved.

A.S.T.M. STANDARDS 1946. PART III-A, NONMETALLIC MATERIALS. COAL AND COKE, PETROLEUM PRODUCTS, AROMATIC HYDROCARBONS, SOAPS, WATERS, TEXTILES, GASEOUS FUELS. *Published by American Society for Testing Materials, Philadelphia 3, Pa., 1947. Cloth, 6¼ x 9¼ in., 1200 pages. Price $8.00; to A.S.T.M. members $6.00.* Contains about 100 standards in the petroleum field while there are some 80 related to textile materials, cotton, wool, etc. Coal and coke are included in another group.

A.S.T.M. STANDARDS 1946. PART III-B, NONMETALLIC MATERIALS. ELECTRICAL INSULATION, PLASTICS, RUBBER, PAPER, SHIPPING CONTAINERS, ADHESIVES. *Published by American Society for Testing Materials, Philadelphia 3, Pa., 1947. Cloth, 6¼ x 9¼ in., 1360 pages. Price $8.00; to A.S.T.M. members $6.00.* Contains well over 250 specifications and tests.

LEARNING TO WELD. *Published by Lincoln Electric Co., Cleveland 1, Ohio, 1947. Heavy paper, 5½ x 8½ in., 32 pages. Price 25c.* This booklet's purpose is to teach one how to weld and to assist in applying arc welding to the repair of broken parts, the hard surfacing of worn parts, and the building of miscellaneous equipment. There are many illustrations, including four pages of 22 pictures of typical applications of arc welding in repair and construction.

MANUFACTURERS LITERATURE

Materials

Iron and Steel

Stainless and Electrical Steel. The many facilities of the Allegheny-Ludlum Steel Corp. for producing stainless and electrical steel are attractively illustrated and described in this 16-page bulletin. (1)

Nonferrous Metals

Copper Contamination in Corrosion Resisting Alloys. Bulletin No. M-5, four pages, discusses the presence of copper as a possible solution contaminator in corrosion resisting alloys, and explains the superior corrosion resistance of Durimet 20, a special stainless steel alloy produced by the Duriron Co., Inc. (2)

Aluminum and Its Alloys. A complete line of "Falls" aluminum and aluminum alloys, their nominal composition and physical properties is presented by the Niagara Falls Smelting & Refining Div. of Continental-United Industries Co., Inc. in a 6-page folder. (3)

Aluminum. The huge and numerous plants of the Permanente Products Co. for producing Kaiser aluminum are pictorially described in this 12-page bulletin. (4)

Large Diameter Brass Rods. Tables showing maximum lengths of large diameter brass rods in various diameters, composition of the alloys in which they are furnished, and specifications are all included in this 4-page, illustrated bulletin just released by the Titan Metal Mfg. Co. (5)

Parts and Forms

Steel-Base Coils. Samples of Electro-Bonded nickel, chromium and copper steel coils, available in widths of 1/8 in. to 24 in., are included in this 4-page, illustrated folder offered by American Nickeloid Co. (6)

Beryllium-Copper Plunger Tips. Engineering Data Sheet No. 147, one page, describes and illustrates Ampco beryllium-copper plunger tips that are machined and heat treated ready to install. Ampco Metal, Inc. (7)

Bronze Bearings, Bars, Etc. Detailed information on a complete line of standard bronze bearings, precision bars, electric motor bearings, graphited oilless bearings and babbitt metals is compiled in an attractive, 64-page, illustrated catalog, No. 46, by the Bunting Brass & Bronze Co. (8)

Special Alloys. Characteristics of the basic Duraloy alloys that apply principally to static or centrifugal castings are included in this 16-page, illustrated bulletin, No. 4729-G, covering special alloys that resist corrosion, high temperatures and abrasion. The Duraloy Co. (9)

Large Forged Nuts. A wide variety of large forged nuts for use in heavy machinery, large construction, locomotives, etc. are described and illustrated in a 4-page bulletin, No. 51, offered by Joseph Dyson & Sons, Inc. (10)

Coil Springs, Rotor Pumps, Etc. A complete line of coil springs, rotor pumps, engine valves, snap rings, dynamatic devices, etc. produced by the Eaton Manufacturing Co. is profusely illustrated and described in a 40-page, pocket-size booklet. (11)

Metal Stampings. The many advantages of using short-run metal stampings in blanking, piercing, forming, drawing, extruding, etc. operations are featured in a 4-page, illustrated bulletin, No. 101, published by the Federal Tool & Mfg. Co. (12)

Permanent Magnets. Complete data on the characteristics, design, properties and applications of G-E permanent magnets are presented by the Chemical Dept. of General Electric Co. in a 36-page, illustrated bulletin. (13)

Precision Castings. This attractive, 20-page bulletin issued by the Michigan Steel Casting Co. describes and illustrates the Misco process for producing carbon and stainless steel precision castings. (14)

Screw Machine Products, Etc. Diversified facilities available at Perry Metal Products Co., Inc. for producing a variety of screw machine products in stainless steel, aluminum, brass, copper, etc.; solid or perforated metal spinning in ferrous and nonferrous metals; metal stamping by drop hammer, hydraulic, automatic and double action presses; centerless and thread grinding; etc. are described in a 2-page, illustrated bulletin. (15)

Steel Cast Tooth Gears and Sprockets. The many advantages of using steel cast tooth gears and sprockets in road and field equipment are given by Racine Steel Castings Co., Div. of Belle City Malleable Iron Co. in a 4-page, illustrated bulletin, No. 4. (16)

Permanent Magnets. The many applications, design and fabrication of permanent magnets are featured in an attractive, 16-page, illustrated bulletin offered by Thomas & Skinner Steel Products Co. (17)

Plastics

Plastics. An attractive, 24-page catalog describes and illustrates the facilities of G. Felsenthal & Sons for producing from blueprint to finished product injection molded and fabricated plastics. Typical applications are included. (18)

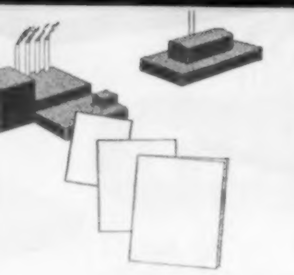
Plastic Surfaced Plywood. Numerous applications of plywood surfaced with Kimpreg, a synthetic-resin cellulose-fiber product designed to provide a smooth, lasting, hard-to-penetrate surface for plywood, are included in this 6-page, illustrated folder offered by the Plastics Div. of Kimberly-Clark Corp. (19)

Injection-Molded Plastics. The many advantages of using the facilities of the F. J. Kirk Molding Co. for precision-molded plastics, and the products they have produced, are listed in this 4-page, illustrated bulletin. (20)

Organic Compound. Complete data on Divinyl Benzene, a flammable organic compound used in the production of resins and plastics, as well as in the manufacture of certain synthetic rubbers, are presented by the Chemical Div. of Koppers Co., Inc. in a 2-page bulletin. (21)

Plastics. Specifications and prices of the latest development of Tennessee Eastman Corp.—Tenite III, a cellulose acetate propionate plastic in pellet and granular form for injection molding and continuous extrusion—are presented in two 4-page bulletins. (22)

Corrosion Resistant Materials and Equipment. A complete line of corrosion resistant materials and equipment, including plastic tubing, plastic and rubber lining materials, protective coatings, jar mills, drum rollers, etc., is described and illustrated in a 16-page bulletin, No. K, just released by U. S. Stoneware Co. (23)



MANUFACTURERS' LITERATURE

Methods and Equipment

Heat Treating

Salt Baths for Heat Treatment. Complete data on the use of salt baths for heat treating and carburizing high-speed steel are presented by American Cyanamid Co. in a 28-page, illustrated bulletin. (24)

Ammonia Dissociator. Typical applications and advantages of using the Drever Company's Ammonia dissociator for providing a protective atmosphere in metal treating furnaces and in the powdered metal field are featured in this 12-page, illustrated bulletin, No. B-51. Specifications are included. (25)

Induction Heater. Several types of the new Model U P Smith-Dolan induction heater used in preheating and normalizing welds, and their wide range of applications, are described in a 4-page, illustrated bulletin, issued by Electric Arc, Inc. (26)

Induction Heating. Numerous case histories of brazing applications, hardening and brazing applications, and hardening and heating applications, using a variety of Thermonic induction generators produced by the Induction Heating Corp. are presented in a group of six illustrated data sheets, Nos. 12 to 17. (27)

Welding and Joining

Oxyacetylene Cutting in Sheet Metal Work. Detailed information from a reprinted article on oxyacetylene cutting in sheet metal work is incorporated in a 12-page, illustrated bulletin, issued by Air Reduction Sales Co. (29)

Adhesives. Numerous applications of Bostik resin-base and rubber-base adhesives are presented by the B. B. Chemical Co. in a 4-page, illustrated bulletin. (30)

Arc Welders. A model and size of multi-range, dual control arc welders for every requirement is described and illustrated in a 4-page bulletin, issued by the Hobart Brothers Co. (31)

Arc Welding Accessories. A complete line of arc welding accessories, including cable connectors, cover plates, eye shields, hammers, protective clothing, etc. is described and illustrated in a 16-page bulletin, No. 120, just released by Metal & Thermit Corp. Specifications are included. (32)

A. C. Welders. Two types of a.c. welders for use with "Heliarc" welding torches are described and illustrated by the Miller Electric Mfg. Co. in their 4-page bulletin. Specifications and prices are included. (33)

Automatic Welding Machine. The Niagara Machine & Tool Works attractively presents their electronic automatic welding machine for plate and sheet metal work in a profusely illustrated, 12-page bulletin, No. 83. Specifications are included. (34)

Resistance Welding. The advantages of using the "Three-Phase" resistance welding process initiated by Sciaky Bros., Inc., are discussed in a 4-page, illustrated bulletin, No. 137-A. (35)

Welding and Cutting Equipment. A complete line of gas welding and flame cutting equipment produced by the Victor Equipment Co. is profusely illustrated and described in a very attractive, 20-page bulletin. Prices are included. (36)

Resistance Welders. A complete line of light gage resistance welders, both bench and floor models from 1 kva. to 7½ kva., is described and illustrated in a 10-page bulletin offered by Weldex, Inc. (37)

Forging and Forming

Interchangeable Punches and Dies. The proper care and use of R-B interchangeable punches and dies in the metal working and plastics industries is illustrated in an interesting cartoon style by Allied Products Corp., Richard Brothers Div. in a 16-page booklet. (38)

Steel Side Trimming Presses. A wide variety of steel side trimming presses, single and double crank, are described in a 12-page, illustrated bulletin, No. 3-L-7, issued by Chambersburg Engineering Co. Specifications are included. (39)

Assembly Presses. An expanded line of hydraulically-operated assembly presses, comprising models from 10- to 50-ton capacity, are featured in a revised bulletin, No. PA-47, offered by Colonial Broach Co. Specifications are included. (40)

Inclinable Hydraulic Press. The many features of the new H-P-M high-speed inclinable hydraulic press are discussed in a 4-page, illustrated bulletin offered by the Hydraulic Press Mfg. Co. Specifications are included. (41)

Punch Presses and Accessories. Ten models of open-back inclinable punch presses, capacities 6 to 90 tons, ball bearing stock reels, pneumatic die cushions, and a safety device, with nonrepeating attachment, are all described and illustrated in a 6-page folder offered by the Walsh Press & Die Co., Div. of American Gage & Machine Co. Specifications are included. (42)

Machining

Grinders, Grinding Wheels, Etc. A complete line of horizontal face grinders, vertical surface grinders, grinding wheels, buffing lathes, cut-off machines, etc. is described and illustrated in a 16-page bulletin, No. 147, just released by the Bridgeport Safety Emery Wheel Co., Inc. Specifications are included. (43)

Grinding Machines. Complete data on Filmatic 6- and 10-in. L plain hydraulic grinding machines for precision cylindrical work are presented by Cincinnati Grinders, Inc. in an attractive, 20-page, illustrated bulletin, No. G-566. Specifications are included. (44)

Portable Grinding Machines. The safe and efficient operation of a variety of types of portable grinding machines is discussed by the Grinding Wheel Manufacturers Assn. in a 20-page, illustrated, pocket-size booklet. (45)

Rotary Files. A complete line of ball, oval, cylindrical, tree, cone and inverted cone rotary files, each in a wide range of diameters and lengths of cut, is presented by the Grobet File Co. of America, in a 16-page, illustrated bulletin. (46)

Boring Tools. Examples of phenomenal time savings in boring and chamfering operations by using Kwik-Size boring tools setups, produced by the Kaukauna Machine Corp., are discussed in a 6-page, illustrated folder. (47)

Grinding and Polishing. The 3-M Backstand Method of finishing metal parts by grinding and polishing is featured in a 16-page, illustrated bulletin, offered by the Minnesota Mining & Mfg. Co. (48)

Contour Boring and Turning Machine. This 6-page, illustrated folder, No. 682, discusses the construction, operation and versatility of the Model 26 precision contour boring and turning machine, produced by the New Britain Machine Co. Specifications are included. (49)

Grinding Carbide Tools. This 138-page, illustrated handbook contains detailed information on how to recondition and sharpen cemented carbide tools and cutters rapidly and economically. Norton Co. (50)

Soluble Oil. The many advantages and economies of using Oakite Soluble Oil as a coolant and lubricant in cutting, machining, grinding and related operations on ferrous and nonferrous metals are listed by Oakite Products, Inc. in a 20-page, illustrated booklet, No. 5239R. (51)

Precision Tools. Specifications are included in this 8-page, illustrated bulletin just published by the Robbins Engineering Co. featuring a variety of precision tools, both magnetic and nonmagnetic, for angular setups. (52)

Hydraulic Follower Machine. This new bulletin just issued by the Turchan Follower Machine Co. shows how their hydraulic follower machine can be used for duplicating dies, molds, patterns or original forms from hard or soft models. (53)

New Materials and Equipment

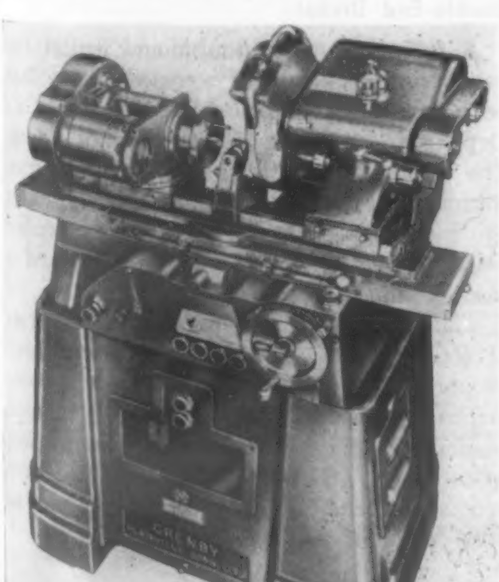
Hydraulic Grinders for Tool Room

Two new hydraulic grinders, a universal external grinder EG-103 and a universal internal grinder IG-103, have been announced by the *Grenby Manufacturing Co.*, Plainville, Conn. Either machine can be equipped with two heads to make a combination external-internal grinder.

The recommended capacities are: external 3-in. dia. by 10 in. long between centers; internal 3-in. dia. by 4 in. long. Both can actually grind work up to the full swing over the table of 9-in. dia.

These grinders are primarily tool room equipment, but due to the accuracy of the stops for maintaining size, lever collet closer, hydraulically operated table, semi-sizing diamond dresser, coolant and other features many are now being used in production.

The regular features include a live spindle work head that takes 5C-1 in. collets, swivels 90 deg. either side of center, taper bayonet lock spindle nose for 3 and 4 jaw chucks, face plates, dead center attachment. The grinding wheel head swivels 15 deg. and a ¾-h.p. motor drives the 10 by 1 in. external wheel or the 15,000 rpm. and 32,000 rpm. internal spindles.



Machine can be equipped with two heads to make a combination external-internal grinder.

Hand and power cross feed in 0.0001 are provided. The table has infinite speed changes from 0 to 100 in. per min. and oscillates a full 10 in. or as little as 1/32 in. and will still power cross feed at either end or both ends of the stroke.

Presses for a Variety of Uses Introduced

Recently announced presses feature many new refinements to speed up production and provide uniform products. Below are described a number of the latest developments.

Designed for pressing requirements between 200 and 2000 lb. ram effort, a new press is being offered by the *Denison Engineering Co.*, Columbus 16, Ohio. The press is suited for multiple or "gang" installations and for successive operation requirements. One centralized power source will operate up to 12 units.

A variety of pressing, straightening, bending, flattening, broaching, assembling and other operations can be performed on the 25-ton hydraulic press manufactured by the *Manco Products Co.*, State & Hay Sts., York, Pa. The press is self-contained and is hand operated. Ram travels ⅛ in. per stroke. Distance between uprights, 30 in.; table travel, 35 in.; ram travel, 4½ in.; ram diameter, 2¾ in.

A new back-geared 31 ton punch press has been announced by *Diamond Tool Co.*, Los Angeles, Calif. Bed area from front to back is 13 in. and from right to left 22 in. Standard stroke is 3 in. although shorter or longer strokes are provided upon request. Overload protection is rated at 100%. The 31 ton press is mounted on heavy semi-steel cast iron legs and a cradle arrangement permits operation of the press at any desired degree of inclination. Gibs, sliding surfaces and crank shaft are micro-finished.

Capable of up to 100 strokes per min., a hydraulic inclinable press developed by *Hydraulic Press Manufacturing Co.*, Mt. Gilead, Ohio, has a pressure capacity up to 50 tons. Pressure is applied by a direct-acting hydraulic ram, incorporating booster rams for rapid traverse. The press closes at 984 in. per min., works at high pressure at 84 in. per min., and opens at 790 in. per min. Ram action provides straight motion without side thrust. Ram speed is adjustable, though constant throughout the working stroke at whatever setting is selected.

New 9, 10, 19, and 30 ton open-back inclinable punch presses with variable control which makes it possible to stroke from 180 to 500 press strokes per min. have been introduced by the *Fast Feed Machine Corp.*, 237 Kunkle Bldg., Ashtabula, Ohio. Among the features cited are: main bronze bearings, running from front to rear of crankshaft; flywheel, located out of operator's working space; motor designed for variable speed control; crankshaft can run in oil bath or grease at high speeds.

Colored Finishes for Polystyrene Surfaces

Development of a line of clear and colored surface finishes for polystyrene plastics has been reported by the *Monsanto Chemical Co.*, St. Louis 4, Mo.

Coating chemists and plastic technicians have reported that the lacquers overcome the tendency of solvents to produce crazing in polystyrene. The lacquers are either clear or pigmented, resistant to oil, and will protect the polystyrene. They were developed to make possible the coating of the face or the back of the clear moldings in color and to provide wipe-in colors for dials, trademarks and decorations.

The lacquers can be sprayed onto the polystyrene surfaces and will dry rapidly to a hard, adherent and mar-resistant finish of high glass suitable for an exterior finish. The wipe-on coatings or coatings applied to inlays, such as dial numerals, letterings and designs, are usually applied with a brush.

Power Press Brake Features Slide Adjustment

A motor-driven slide adjustment with both motor and controls readily accessible is reported an important feature of the power press brake produced by *Columbia Machinery & Engineering Corp.*, Hamilton, Ohio. The slide can be adjusted out of parallel with the base, the magnitude of the adjustment showing on indicators located on each end.

The brake is operated by a multiple-disk friction clutch of special design and a highly-efficient friction brake. The slide and base have been designed for strength and rigidity with a maximum permissible deflection of 0.001 in. per ft. of machine width. The housings, slide, base and cross tie are fabricated from rolled steel.

The power press brake shown here is of 120 tons capacity.

All gears are precision machine cut and operate in oil within an oil-tight case. First driving gears are helically cut. The eccentric shaft is a heat-treated high-carbon steel forging with eccentrics forged integrally with the shaft. All main bearings are lubricated by a positive centralized lubricating system.

The brake is of 120 tons capacity and operates at a speed of 30 strokes per min. It will form mild steel in the following sizes: 7/16 in. by 4 ft., 5/16 in. by 6 ft., ¼ in. by 8 ft. and 3/16 in. by 10 ft.

Die Casting Machine Convertible to Hot Chamber Unit

A new size and style of hydraulic operated die casting machine, designated Model HD-302, is being offered by the *H. L. Harvill Manufacturing Co.*, Corona, Calif.

This machine is a heavy duty type, convertible from normal cold chamber operation to optional hot chamber operation.

As a cold chamber machine the equipment normally casts aluminum, magnesium and copper-base alloys although zinc, tin and lead alloys may also be cast cold chamber. These alloys are hand-ladeled by the operator from a holding furnace adjacent to the machine into the "cold-chamber" injection assembly. As many as 300 injections of molten metal may be made per hour. The metal is injected into the die cavities under pressure ranging from 3400 up to 11,800 psi.

The machine is capable of casting up to 11.6 lb. of aluminum alloy, or an equivalent volume of other materials.

The machine is converted to hot chamber operation by installation of a special self-contained conversion unit. The conversion unit consists of: (a) a holding furnace beneath the injection cylinder, (b) a blower and temperature control unit, (c) a metal pump assembly with motor, and (d) a hot chamber injection assembly. This injection assembly is not immersed in the molten metal, consequently is not subject to deterioration as in the case of ordinary "goose-neck" assemblies.

Assembly Press Suitable for Delicate Parts

A 10-ton hydraulically operated assembly press has been announced by *Colonial Broach Co.*, Box 37, Harper Station, Detroit 13. With a maximum adjustable stroke of 12 in., the press has a power stroke speed of 180 in. per min. with a return stroke of twice that amount. Ram speeds are adjustable over a wide range, however.

Working pressure is 1200 psi. maximum, and is adjustable through a knurled dial on the front of the machine to any desired amount below this. This feature is particularly advantageous when assembling relatively delicate parts. Desired pressure can be selected and maintained through a direct reading pressure gage adjacent to the pressure control regulator. The machine requires 25 by 42 in. of floor space and is operated through a 7½ h.p. motor.

Standard equipment on the press includes hand operating control and pressure gage. Foot pedal control, for use where operators are required to have both hands free, is available as extra equipment, as are various pressure and speed controls to suit individual needs.

New 10-ton assembly press has a maximum working pressure of 1200 psi.

Many New Developments to Be Featured at Machine Tool Show

This month at the Machine Tool Show in Chicago many new machine tool developments will be unveiled. A number of these are described here, along with other recently introduced machine tools.

Contour Boring and Turning Machine

A new contour boring and turning machine to perform precise second operation work has been developed by *New Britain-Gridley Machine Div., New Britain Machine Co.*, New Britain, Conn. In addition to straight boring and turning, facing and chamfering, the compound action obtained from contours on the two cams directs the single point tool in producing lands, steps, recesses, flanges, counterbores and radii. This tool is fed free to the bottom of the bore and cuts on the drawback stroke.

This contour boring and turning machine requires only one dimension of its work to be inspected. (New Britain)

For jobs too complicated for a single point tool, a tool cluster can be arranged. Either work or tool may be held in the spindle to adapt it to a wide variety of work. Two different sized models are made and spindle speeds up to 6000 rpm. are available.

Double-End Driller

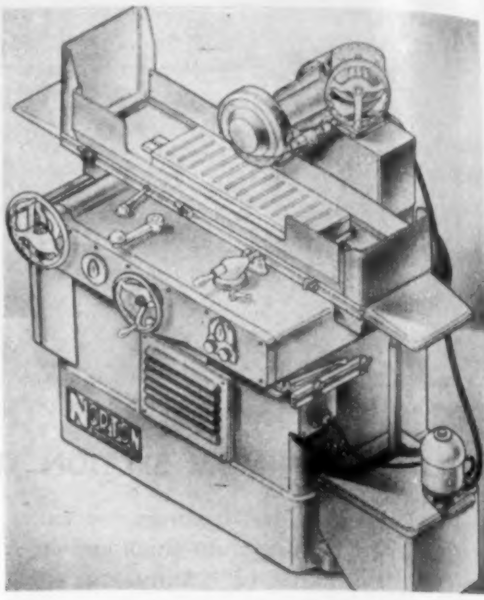
A fully automatic double-end driller for production drilling of crossed holes has been announced by *Buhr Machine Tool Co.*, Dept. K, 826 Green St., Ann Arbor, Mich. The machine is hopper fed, drills, reams, countersinks and checks at desired angles by indexing the collets in an indexing turret, providing eight work stations and a loading and unloading station.

The driller can be operated in batteries of four by one operator; parts are loaded in one "bulk" handling, and ejected automatically. The original machine, developed to drill, ream and countersink two lacing holes in a 5/16-in. bolt, is reported to have produced at the rate of 960 pieces per hr. at 80% efficiency.

Hydraulic Grinders

A new light type 8- by 24-in. hydraulic surface grinder has been designed for tool room or production work within its capacity by *Norton Co.*, Worcester, Mass.

The machine is arranged with horizontal spindle, hydraulic and hand table traverse and automatic hydraulic cross feed. An anti-friction cartridge type spindle is standard, but a sleeve bearing type is available if desired.



A new light type grinder designed for tool room or production work. (Norton)

The automatic cross feed permits easy adjustment and accurate, smooth operation. The hydraulic system is so arranged that the cross feed can be operated with the work table stationary to permit wheel truing.

The 10- by 20-in. universal grinding machine is also a new addition to the Norton line. It is designed for miscellaneous, general production or tool room work where the diversity of grinding requires a universal machine.

In the wheel head, interchangeability of belts permits mounting a cylindrical grinding wheel on either end of the work spindle. The machine incorporates a self-contained headstock and both internal and external wheel spindles. A hinging feature of the internal spindle bracket requires no more than clamping in the down or locking in the up position, and a separate motor drives this internal spindle. Full rotation of the wheel head through 360 deg. is provided.

Spindle Machine with Electronic Controls

A spindle machine with complete electronic controls and four-way bed is being featured by the *Lucas Machine Tool Co.*, Cleveland. This machine can be operated from any position by pendant control. The electric system has been developed to include all movements of the head, spindle, table and saddle. The speeds and feeds of the machine are manually set but the control of all the movements are through a pendant control station which is movable to any position desired by the operator.

Belt Grinder

A belt grinder for grinding and polishing of contours, and maintaining a sharp, fully machined pattern, has been developed by the *Porter-Cable Machine Co.*, Syracuse, N. Y. In the grinder a flexed abrasive belt approaches and leaves a formed contact roll at a slight angle. The abrasive belt "drapes" itself into the pattern on the roll and grinds-polishes that pattern sharply.

The contact roll, designed for the pur-

The surface speed of this belt grinder remains constant, regardless of the diameter of the contact roll. (Porter-Cable)

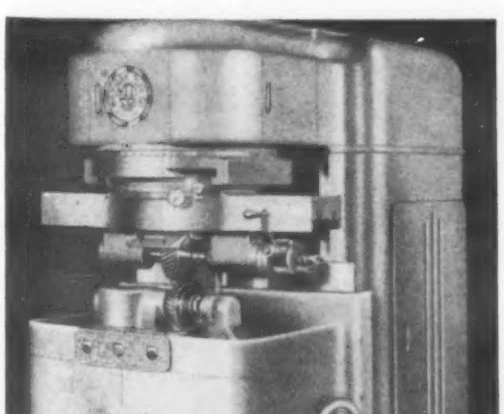
pose, is made of sisal and latex. The grinder accommodates a 148-in. abrasive belt. Its contact roll is not a driving force, but an idler, thus heat, motor and shaft vibration which have caused considerable grinding difficulties in the past are avoided.

Band Sawing Machine

A new hydraulic band sawing machine employing a high-speed steel endless blade (1½ in. wide and 0.072 in. thick) has been announced by *Armstrong-Blum Mfg. Co.*, 5700 W. Bloomingdale Ave., Chicago 39. The machine is equipped with a torque-control valve that automatically adjusts the feed pressure to hold a constant pulling load on the blade regardless of the size and regardless of the changing area or shape of the work as it is being cut off. The machine also has full hydraulic direct drive, hydraulic feed, and hydraulic work clamping.

Gear Finishers

A new line of production crossed-axis rotary gear finishers, consisting of two models in three sizes each, has been announced by *Michigan Tool Co.*, 7171 E. McNichols Rd., Detroit 12. The finishers permit selection of any one of three differ-



The finishers permit selection of any one of three different methods of gear finishing. (Michigan Tool)

ent methods of gear finishing. The three methods are: underpass shaving, in which the work moves tangential to the cutter; transverse shaving, in which the work is reciprocated axially, while feed is radial; traverpass shaving, a new development representing a combination of underpass and transverse shaving.

The new machines are available in three sizes, handling respectively gears up to 8, 12 and 18 in. Minimum diameter is 1 in. in all cases, with maximum face width of 5 in. on standard centers. Distance between centers (maximum) is 26½ in., and the machines will take cutters up to 10 in. dia.

Broaching Machines

Three new lines of broaching machines have been developed by *Colonial Broach Co.*, Box 37, Harper Station, Detroit 13. The new lines consist of both pull-up and pull-down broaching machines as well as a new line of single ram surface broaching machines. All machines are of the vertical type and are offered in a complete range of standard tonnages and strokes.

They have a new hydraulic system layout. Hydraulic pumps are mounted outside of the machine housing, where they are accessible for adjustments, inspection or service. For protection, they are provided with a light weight enclosure. A new air circulation system for the motors and hydraulic system provides maximum cooling, permitting sustaining of high peak loads.

Four New Lathes

Four new lathes, have been announced and will be exhibited by the *R. K. LeBlond Machine Tool Co.*, Cincinnati 8, Ohio. The new lathes are the 16 in. Model RT heavy duty lathe with single lever control headstock, the 16 in. Model RT heavy duty lathe with variable speed headstock, the 25 in. heavy duty engine lathe, and the dual drive lathe.

The first is a combination gear-belt drive lathe with hardened and ground steel gears throughout headstock; with a single lever controlling 16 spindle speeds ranging from 20 to 1025 rpm., or 30 to 1537 rpm.

The second offers a large number of spindle speeds ranging from 6 to 1500 rpm.

Dual drive lathe has one-piece apron with positive jaw feed clutch. (LeBlond)

and has hardened and ground steel gears throughout the headstock.

The third has a totally enclosed and automatically lubricated quick change box. Forty-eight changes of feeds and threads may be obtained without change gears from the direct-reading plate mounted above tumbler shifter.

The last is a combination gear-belt drive headstock lathe with a single lever controlling 12 spindle speeds ranging from 28 to 1800 rpm., totally enclosed and automatically lubricated quick change box which provides 48 feed and thread changes.

High Speed Lathes

Two new machine tools will be exhibited by the *Bullard Co.,* Bridgeport 2, Conn. They are: a three-spindle horizontal lathe which introduces a new principle in shaft turning and which is operated automatically through 39 different functions by the Man-Au-Trol Control at spindle speeds up to 1,200 rpm., and, a high-speed development of the standard multiple-spindle machine tool. The latter is known as Type K and makes available the Mult-Au-Matic production principle in units with six, eight, twelve or sixteen spindles operating at speeds up to 900 rpm.

Light Duty Engine Lathes

A new series of light motor driven geared head engine lathes has been announced by *Cincinnati Lathe & Tool Co.,* Oakley, Cincinnati 9. They are designed as general purpose lathes to handle a variety of turning, boring and threading operations either for long or short run lots. The lathes are offered in four nominal swing sizes, namely, 10, 12½, 15 and 18 in. with distances between centers from 18 in. and up in increments of 6 in.

The standard range of speeds on the 10 and 12½ in. size machines is from 30 to 1200 rpm.; the standard range on the 15 and 18 in. size machines is from 20 to 820 rpm. in geometrical progression with an overall ratio of 41 to 1. Optional high spindle speed ranges are available.

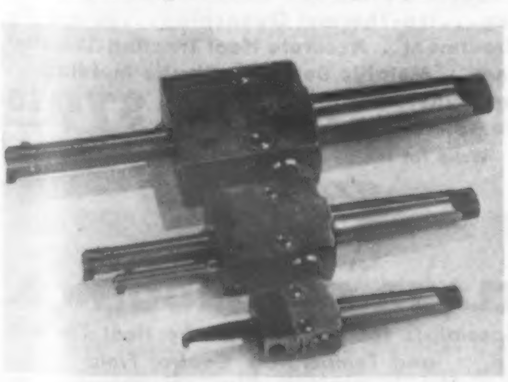
Grinding and Polishing Machine

A line of 2-roll vertical abrasive belt grinding and polishing machines for flat polishing of ferrous and nonferrous metals and other materials has been introduced by the *Hill Acme Co.,* 6426 Breakwater Ave., N. W., Cleveland 2.

They are available in three general types. (1) Strip type for processing strip material in coiled form. (2) Plate or bar type which incorporates the use of feed or pinch rolls for conveying the material under the polishing head. (3) Sheet type with reciprocating hydraulic table drive. Machines are built in a progression of widths up to a maximum of 60 in. Endless coated abrasive belts 10 ft. 6 in. long are utilized.

Adjustable Boring Heads

Development and production of a line of adjustable precision boring heads has



These boring heads are small, rigid and compact. (Maxwell)

New Literature

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PROTECTIVE MATERIALS FOR BOILERS

1 FUEL OIL TREATMENT – Illustrated 4-page bulletin discussing Petroflo, liquid fuel oil treatment, which cleans fuel system from storage tank to burner tip and makes manual tank cleaning unnecessary. Discusses industrial applications. XZIT Sales Company.

2 REFRACTORY COATING – Bulletin provides general information about Brickseal Refractory Coating, a combination of high-fusion clays and metal oxides mixed in oil which forms a highly glazed protective coating for refractory brick of all kinds. Shows uses, grades and results. Brickseal Refractory Co.

3 METAL PROTECTION – Fact-filled 4-page brochure explaining use of Serviron Metal Protector, a grease-like semi-plastic material which can be brushed or sprayed on metals for protection from weather, brines and alkalies. Especially suited to protecting and lubricating railroad switches, signals, and track parts. Serviron Metal Protector Company.

4 SOOT REMOVER – Attractively prepared bulletin contains considerable data on the use of XZIT Firescale & Soot Remover in industrial and marine fields. Shows stack temperature comparisons before and after using product. Offers five ways of reducing boiler operating costs. XZIT Sales Co.

5 REFRACTORY COATING – Bulletin gives information about the use of Vango Refractory Coating in crucibles, pouring ladles, forging and heat-treating furnaces. Discusses application, uses and effectiveness for all types of firebrick, cast or plastic refractories. Vango Refractory Company.

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MATERIALS & METHODS Box 900
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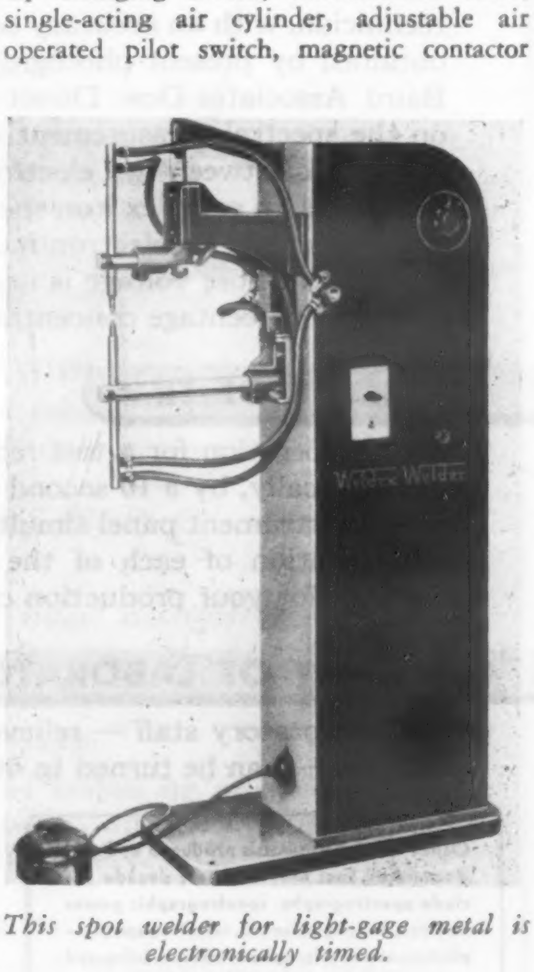
been announced by the *Maxwell Co.*, 360 Broadway, Bedford, Ohio. Heads are designed to handle a wide range of work on boring, drilling and milling machines and automatics. Standard line of boring heads includes three sizes for cutting holes up to 15 in. in dia.

Each tool has tool-steel adjusting head which is graduated into 50 divisions to provide readings in thousandths of an inch and body of head is graduated to give vernier readings of 0.0002-in. Boring heads can be furnished with cemented carbide tips. Standard tools can be used for rough and finishing operations.

Light Gage Spot Welder Available in Two Models

A new high-speed, automatic, air operated, spotwelder series consisting of two models has been announced by *Weldex, Inc.*, Dept. K, 7307 McDonald Ave., Detroit, 10. Model 752-P is a press action type, Model 752-R is a rocker arm type. Rated at $7\frac{1}{2}$ kva., both models have been designed with a high power-space ratio for continuous production welding on thin metals up to two thicknesses of 14-gage cold rolled steel or equivalent.

The welders have a built-in transformer, tap changing switch, solenoid air valve, single-acting air cylinder, adjustable air operated pilot switch, magnetic contactor



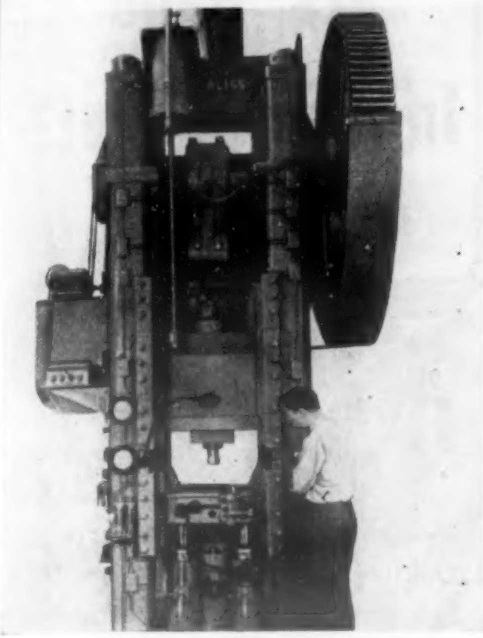
This spot welder for light-gage metal is electronically timed.

and electronic timer which automatically control all phases of the welding cycle.

Standard equipment on each model includes: adjustable air pressure regulator, brass air strainer, pressure gage, movable push button foot-switch, water-cooled electrode holders and special alloy, water-cooled welding tips.

Briquetting Press for Complex Powdered Metal Parts

A new briquetting press that extends metal powder application to large, irregular cross-sections has been developed by the *E. W. Bliss Co.*, 450 Amsterdam Ave., Detroit 2. Embodying an operating principle which combines the advantages of triple hydraulic lower motion built into a 345-ton mechanical press, the press is said to produce large, complex powdered metal parts beyond the size range and capacity of



This briquetting press combines triple hydraulic lower motion (floating die table, core rod and stripper) built into a 345-ton mechanical press.

available single-action mechanical or hydraulic presses, and to close tolerances.

To obtain uniform density throughout the finished part there is a hydraulically controlled floating die table and core rod rams, which recede against pressure that is pre-determined by independent adjustments. This has the effect of squeezing the powder from the top and the bottom.

The mechanically actuated slide has a 10-in. stroke, which can be adjusted to 5 in. This slide carries an adjustable cam which actuates the movement of the powder hopper.

The speed of the slide can be adjusted from 6 to 9 strokes per min. and from 9 to 18 strokes per min. by adjusting the speed control of a variable speed motor. The change from the low range to the high range, or vice-versa, is made by shifting a dog clutch in the two-speed gear box by means of an external lever.

Specifications of the Bliss No. 309 briquetting press include: capacity of slide, 345 tons; die table, 120 tons; core rod, 60 tons; stripper (eject up), 75 tons; stroke of slide, 10 in.; die table, 3 in.; core rod, 3 in.; stripper, 6 in.

● A low-temperature welding rod for use on zinc-base die castings is available in 3/32-in. dia., round form from *All-State Welding Alloys Co., Inc.*, 96 West Point Rd., White Plains, N. Y. The rod has a working temperature of 400 F; it has a shear strength of 25,000 lb. per sq. in. It can be used with or without a flux.

News of...

ENGINEERS COMPANIES SOCIETIES

Engineers

Berton H. De Long has been appointed vice president and technical director, Carpenter Steel Co., while *George B. Luerssen* has become chief metallurgist. Mr. De Long has been with Carpenter since 1910 and was previously vice president and chief metallurgist. Mr. Luerssen has been with the company since 1907 and was assistant chief metallurgist.

Elmer E. Sheldon has been made quality control engineer, General Electric's Wire & Cable Div., having been with the company since 1937.

Richard M. Paxton, Jr. has been elected a vice president, Jessop Steel Co., having served in all of the company's production departments and laboratories.

James W. Kinnear, Jr., has been made executive vice president, Firth Sterling Steel Carbide Corp., having been assistant manager of operations, Pittsburgh district, Carnegie-Illinois Steel Corp. He started with Carnegie in 1923 and among his positions has been chief metallurgist and assistant general superintendent. During the war he was occupied with alloy steels and armor plate. His father was one of the founders of Firth Sterling.

Phillip J. Maddex, chemical engineer, has joined Battelle Memorial Institute where he will do research in nonferrous metallurgy. He was formerly an engineer with Ken-Rad Tube & Lamp Corp.

Peter Bryk, of Outokumpu Oy., Pori, Finland, has been inspecting copper and brass mills in the United States. One of the products of his company is oxygen-free, high-conductivity copper, which, however, he is obligated to turn over completely to Russia because of a post-war settlement agreement.

Charles D. Elliott has joined Herbrand Div., Bingham Stamping Co., as assistant to the manager. He has an extensive background in the drop forging, foundry, machine and sheet metal stamping fields.

News of...

ENGINEERS COMPANIES SOCIETIES

Robert O. Bullard has been made manager, Metallurgy Div., General Electric's chemical department, having been engineering and manufacturing manager of that division since last November. He joined the company in 1930.

Louis J. Rohl is now chief metallurgical engineer, Carnegie-Illinois Steel Corp., succeeding *E. T. Barron* who retired after 42 years with Carnegie. He became assistant chief metallurgical engineer last April and has been with Carnegie since 1905.

John F. Cunningham, Jr. has been made manager of the J. P. Devine Mfg. Co. plant at Mt. Vernon, Ill., having been research engineer and manufacturing division engineer, Elliott Co., Jeannette, Pa., during the development of the first gas turbine power plant built in America.

Joseph J. Mayer has been elected vice president and director, Lumen Bearing Co., Buffalo, to succeed the late *C. H. Bierbaum.* He will continue to serve as general superintendent, as for the last ten years. He will also direct the technical and engineering work.

Joseph F. Chalupa is now manager of design engineering, Westinghouse Aviation Gas Turbine Div., Lester, Pa. He joined Westinghouse in 1930 and was assigned to layout and design of steam turbines.

B. E. Schroeder has been elected vice president of manufacturing, Hotpoint, Inc. He has been with General Motors since his start as a production worker in 1924. *Patrick W. Ryan* has been promoted to general superintendent and *M. E. Maurer* has been made general manufacturing engineer.

Albert H. Bump has been named to a new position in industrial research by Monsanto Chemical Co., called senior scientist. The position was created for men of unusual achievements and abilities and to give freedom for original research, unhampered by more limited industrial activity. Mr. Bump had been assistant research director, Merrimac Div., Monsanto, at Everett, Mass.

Reginald G. Standerwick, engineer of General Electric's Aircraft Gas Turbine Div., Lynn, Mass., has retired after 38 years of service. He was in charge of the group that developed the I-16

News of...

ENGINEERS
COMPANIES
SOCIETIES

jet engine and the I-40 engine. He was born and educated in England.

Raymond R. Ridgway, assistant director of research, Norton Co., died June 12 in a sailboat accident in Niagara River. He was an outstanding researcher in electrochemistry and had a long list of inventions in design of electric furnaces for production of abrasives, improvements in manufacture of fused alumina, silicon carbide and magnesia and production of hard metal carbides. He discovered Norbide and the new abrasive 32 Alundum.

Companies

Over 750 engineers, physicists and chemists, recent graduates of 150 U. S. colleges and universities, have been accepted for employment this year by *General Electric Co.,* nearly twice the normal new collegians.

The partnership of *Brooks & Perkins* has changed legal form, with an "Inc." now added, operations in fabricating magnesium to continue at 1957 W. Lafayette, Detroit. A large rolling mill was recently purchased and soon rolling of sheet magnesium will be added. E. Howard Perkins, president, has spent 20 years in fabrication of light metals and pioneered in commercial deep drawing of magnesium.

The *Meehanite Metal Corp.* has concluded three new contracts for manufacture of Meehanite castings with *Standard Foundry Co.,* Worcester, Mass., *Shenango-Penn Mold Co.,* Dover, Ohio, and *K. L. Tractors Pty., Ltd.,* Tasmania.

Scomet Engineering Co. has recently closed an agreement with *Ajax Engineering Corp.* whereby the latter will manufacture Scomet furnaces, which are a departure from the traditional induction furnace for melting metal as they can be built in larger sizes. The company expects to be making them up to 1800-kw. capacity. *Birlec, Ltd.,* Tyburn Rd., Erdington, Birmingham, England, has closed an agreement with Scomet and Ajax for making them for aluminum in the United Kingdom.

The *Precision Castings Co., Inc.,* Fayetteville, N. Y., has purchased a government magnesium die castings

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plant which it operated for the government during the war, the purchase price having been $278,000. The company will produce both aluminum and zinc die castings there.

David F. Sklar, formerly with *Wilson Mechanical Instrument Co., Inc.* for 14 years, as chief design and development engineer, has formed the *Kent Cliff Laboratories,* P. O. Box 696, Peekskill, N. Y., to do consultation, development and manufacture of hardness testing equipment and associated apparatus.

A new research laboratory and test plant is being erected by *Hanson-Van Winkel-Munning Co.* at Matawan, N. J. A maximum of natural lighting, acoustical facility, mechanically filtered air ventilation and the studied use of materials will make for a congenial environment for creative work.

"Golden Horizons" is a 16-mm., 33-min. film put out by *Ampco Metal, Inc.,* 1745 S. 38th St., Milwaukee 4, telling of the development of copper-base alloys from prehistoric days. It is being furnished gratis to technical groups.

Federated Metals Div. recently put into full operation at Los Angeles its new plant for production of intermediate zinc. A feature of the process is the palletizing of the zinc slabs for customer convenience by casting specially shaped slabs for the bottom pieces.

The *Permanente Metals Corp.* has entered the building materials field with a new alloy especially designed for roofing and siding for farms, residential and industrial application. It has also established a pig and ingot division to serve fabricators who operate their own foundries.

Carbomatic Corp., maker of electric or gas infra-red units, is moving its company headquarters to 24-81 47th St., Long Island City 3, N. Y.

Barium Steel Corp. has bought the plant and other assets of *George King Co., Inc.,* Sheffield, Ala., maker of iron and steel castings, marking the entrance of Barium into the Southern industrial field.

Principles and applications of radio frequency heating in industry are explained in a new 16-mm. sound motion picture filmed by *Film Section, Westinghouse Electric Corp.,* 511 Wood St., Box 868, Pittsburgh 30.

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North American Philips Co., Inc. has acquired a new 2½-story concrete factory building in Mt. Vernon, N. Y.

The *Standard Tube Co.,* Highland Park, Mich., will erect a brick and steel frame factory costing $875,000, the company to begin production of its electrical resistance welded steel tubing about Nov. 15.

General Electric has completed a new plant at Pittsfield, Mass. for the manufacture of magnesium oxide used principally in industrial heating equipment as an insulator between central heating wires and metal sheaths, withstanding temperatures as high as 5000 F.

H. William Kranz, Jr., and Edmund G. Siess, Jr., have formed a firm of manufacturer's agents, known as the *Industrial Products Sales Co.,* 1659 W. Market St., Akron 2, Ohio. They will handle principally forgings, iron and steel castings, stampings, screw machine products, stamped and cast industrial wheels; also plastics. Mr. Kranz was formerly with American Steel & Wire Co. as supervisor of new products, market development division. Mr. Siess has been with A. Schroeder & Sons and has represented several concerns in industrial sales.

Societies

An attendance of over 100,000 is expected at the machine tool show, sponsored by the *National Machine Tool Builders Assn.,* in the Dodge-Chicago plant, Chicago, Sept. 17 to 26. Already registrations have been received from 22 foreign countries. An official party of 30 from the *British Machine Tool Trades Assn.,* will arrive on the Queen Elizabeth. Several noted speakers will talk, including Charles F. Kettering, James F. Lincoln, Fulton Lewis, Jr. and Brooks Emeny, president, *Foreign Policy Assn.*

The National Research Corp., in cooperation with the *Division of Industrial & Engineering Chemistry, American Chemical Society,* will hold a high vacuum symposium at Hotel Commander, Cambridge, Mass., Oct. 30 and 31. Among the papers will be one on "Vacuum Metallurgy," by John Chipman, head, Dept. of Metallurgy, Massachusetts Institute of Technology.

An English research center, similar to Battelle, Armour, Mellon, etc. in the United States, has been opened at Stoke Poges, Buckinghamshire, Eng-

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land, known as *Fulmer Research Inst., Ltd.* The present staff totals 40.

The *Magnesium Assn.* has changed its annual convention date from October, 1947 to March 18 and 19, 1948, because of conflict with other meetings. The convention and exhibit will be held at the Pennsylvania Hotel, New York.

Meetings and Expositions

NATIONAL PETROLEUM ASSOCIATION, annual meeting. Atlantic City, N. J. Sept. 17-19, 1947.

NATIONAL MACHINE TOOL BUILDERS' ASSOCIATION, Machine Tool Show. Chicago, Ill. Sept. 17-26, 1947.

ASSOCIATION OF IRON & STEEL ENGINEERS, annual meeting. Pittsburgh, Pa. Sept. 22-25, 1947.

GRAY IRON FOUNDERS' SOCIETY, annual convention. Milwaukee, Wis. Oct. 2-3, 1947.

PORCELAIN ENAMEL INSTITUTE, annual meeting. Cleveland, Ohio. Oct. 9-10, 1947.

ELECTROCHEMICAL SOCIETY, fall meeting. Boston, Mass. Oct. 15-18, 1947.

NATIONAL LUBRICATING GREASE INSTITUTE, annual convention. Chicago, Ill. Oct. 16-18, 1947.

NATIONAL CONFERENCE ON INDUSTRIAL HYDRAULICS, annual meeting. Chicago, Ill. Oct. 16-17, 1947.

NATIONAL METAL EXPOSITION, Chicago, Ill. Oct. 18-24, 1947.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Fuels Division meeting. Cincinnati, Ohio. Oct. 20-22, 1947.

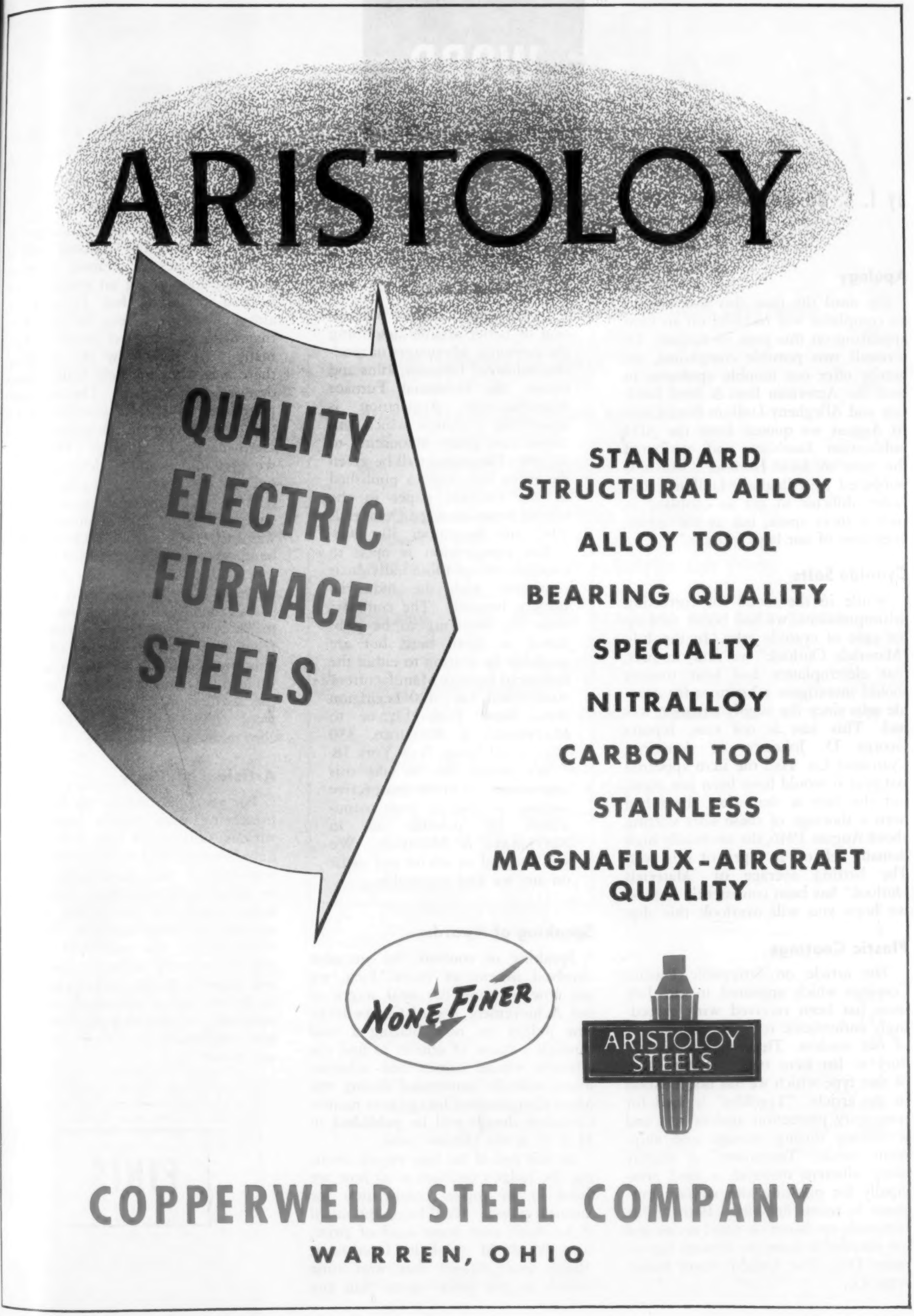
AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, Iron & Steel and Institute of Metals Divisions. Chicago, Ill. Oct. 20-22, 1947.

AMERICAN INDUSTRIAL RADIUM & X-RAY SOCIETY, annual meeting. Chicago, Ill. Oct. 20-24, 1947.

AMERICAN SOCIETY FOR METALS, annual meeting. Chicago, Ill. Oct. 20-24, 1947.

AMERICAN WELDING SOCIETY, annual meeting. Chicago, Ill. Oct. 20-24, 1947.

NATIONAL METAL CONGRESS. Chicago, Ill. Oct. 20-24, 1947.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NITRALLOY
CARBON TOOL
STAINLESS
MAGNAFLUX-AIRCRAFT QUALITY
NONE FINER
ARISTOLOY STEELS
COPPERWELD STEEL COMPANY
WARREN, OHIO

The Last WORD

by T. C. DU MOND

Apology

Up until the time this was written no complaint was received on an item appearing on this page in August. To forestall two possible complaints, we hereby offer our humble apologies to both the American Iron & Steel Institute and Allegheny-Ludlum Steel Corp. In August we quoted from the AISI publication *Steelways* and attributed the item to *Steel Horizons,* which is published by Allegheny-Ludlum. It is rather difficult to get so confused in such a short space, but as the saying goes "one of our boys made it."

Cyanide Salts

While in the mood for correcting misimpressions, we had better take up the case of cyanide salts. In the July "Materials Outlook" we said, in part, that electroplaters and heat treaters should investigate substitutes for cyanide salts since the supply situation was bad. This just is not true, reports George D. Johnston of American Cyanamid Co. Had the item appeared last year it would have been just right, but the fact is that after there had been a shortage of these salts starting about August 1946, the artificially high demand fell off in April of this year. The batting average of "Materials Outlook" has been consistently high so we hope you will overlook this slip.

Plastic Coatings

The article on Strippable Plastics Coatings which appeared in our July issue has been received with exceedingly enthusiastic response on the part of our readers. Thus, we feel it our duty to list here two more products of that type which we did not mention in the article. "Tygofilm" is used for temporary protection against rust and scratching during storage and shipment, while "Temprotec," a slightly more adherent material, is used principally for mashing and stop-off purposes in metal finishing. Both of the materials are based on vinyl resins and are obtainable from the Process Equipment Div., The United States Stoneware Co.

IFMA Prize Contest

In an effort to secure publication of better articles describing the economic advantages of modern industrial furnaces, kilns and ovens, the Industrial Furnace Manufacturers' Association is sponsoring a contest which will award cash prizes amounting to $1,500. The prizes will be given the three best articles published in any business paper in the United States between October 1, 1947 and September 30, 1948.

The competition is open to everyone except those individuals connected with the industrial furnace business. The complete rules are too long to be published in detail here, but are available by writing to either the Industrial Furnace Manufacturers' Association, Inc., 420 Lexington Ave., New York 17, or to MATERIALS & METHODS, 330 West 42nd Street, New York 18.

We would like to take this opportunity to invite prospective authors to send us their manuscripts for possible use in MATERIALS & METHODS. We will be glad to advise and assist on any we find acceptable.

Speaking of Awards

Speaking of contests, we are now involved in two of them. First, we are now entering the final stages of our Achievement Award Competition. The judges are now blazing a trail through a forest of entries to find the winners whose names and achievements will be announced during the Metal Congress in Chicago next month. Complete details will be published in M & M in the October issue.

At this end of the line we are awaiting the judge's decision as to how we fared in an annual competition for business papers. We'll be disappointed if we don't earn some kind of prize, since M & M (and its forerunner, *Metals and Alloys*) has won nine awards in past years—more than any other publication. That's a record we are proud of and hope to better year after year.

Foreign Report

One of our contributors stopped in the other day to tell us about some of his experiences in France, Germany and England during an extended stay he had just concluded. He said that although we have been led to believe that many of the steel plants in Germany were ruined by our bombing, there was comparatively little damage done to most of them. The only complete ruins of a steel plant he saw was one worked on in Belgium as the Germans passed through. This plant, we were told, is totally destroyed without any structures or equipment intact.

As to technical progress in the two countries visited on the continent, there was little to be learned. On the other hand, we are to be depended upon for much information on materials and the methods of processing them for many years to come. One interesting development concerned the extraction of oil from shale through the use of molten aluminum. Low grade shales are thus utilized. After oil has been extracted the residue is converted into mineral wool which is reputed to have many admirable qualities.

Article Popularity

For some 30 months we have been presenting each month manuals on various subjects in our field and all have been received with an enthusiastic response—if our correspondence can be relied upon as a gage. One of the latest starters in the series was the manual on high-strength, low-alloy steels, which was published in July, and if the early demand continues it will prove to be the most popular yet. At the moment of writing about 12,000 reprints have been ordered. That record was established in a little more than one month.

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